





ISSN:0015-3001

MD
25.10.79

FISHERY TECHNOLOGY

JANUARY 1979

VOLUME 16, No. 1



SOCIETY OF FISHERIES TECHNOLOGISTS (INDIA)

Fishery Technology



January 1979

Volume 16, No. 1

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The Indian Council of Agricultural Research, New Delhi has given a generous grant of Rs. 7,500/- for 1978-1979 towards the publication of Fishery Technology.

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Observations on the Wastage of Raw Material and Recovery of Meat in the Prawn Processing Industry

A. K. KESAVAN NAIR, P. SRINIVASA RAO, G. R. UNNITHAN and P. N. R. KAIMAL

Central Institute of Fisheries Technology, Cochin-682 029.

The wastage of prawns due to spoilage in processing factories accounted to about 0-12% in 1974, 0-35% in 1975, 0-3% in 1976 and 0-4% in 1977. Spoilage increases with the time lag between catching and processing and also due to defective icing. The paper discusses the counts of whole prawns required for obtaining meat of specified size grades.

The delay in processing the prawns in factories soon after it is caught accounts to considerable wastage owing to spoilage. It is essential to control this phenomenon not only to conserve the material but also to improve the quality of the finished product. Rao & Pillai (1967) have indicated correlation between the occurrence of defective pieces at pre-freezing and earlier stages. The present study conducted during 1974-'77 aims at factors responsible for wastage and the counts of whole prawns required for a specified size grade by the processing industry.

Materials and Methods

Observations on wastage at processing factories, primary processing centres (P.P.C.) and landing centres were made during 1974-1977. About 10% factories in and around Cochin were covered in this study. The number of factories/P. P. C. observed varied between 5 and 17 over the years and the number of observations between 19 and 65. The sources of raw material were the local catches and those brought from the landing centres of east and west coasts. On an average two observations were made per week. When all the selected factories were covered, a second round was made followed by a third one and so on. The quantity of prawns processed each day from morning to noon and the materials spoiled were noted. The percentage of spoiled material by weight was also calculated. To observe the recovery of size grades, about 235 observations on the counts of whole prawns were carried out and the percentage yield by weight of the different size grades obtained

on peeling/cooking and peeling were recorded. Three factories/P. P. C. where regular records of yield in different size grades were kept were also visited.

Results and Discussion

The main cause of wastage was due to spoilage of the raw material. About 1% lost during washing and handling. There was no wastage during the other stages of processing. Discolouration and damage were noticed but these did not account to any wastage. Table 1 presents the species-wise spoilage by weight (percentage) in factories/P. P. C. during 1974-77. The range of spoilage was observed to be 0-35% in 1975 and 0-3% in 1976. Of the 5 species *Metapenaeus dobsoni* (Poovalan), *Parapenaeopsis stylifera* (Karikadi), *Penaeus indicus* (Naran), *Metapenaeus affinis* (Kazhanthan) and *Penaeus carinatus* (Kara), the first three formed the bulk of the material processed in factories. Spoilage of material reduced from 12.5% and 35% in 1974 and 1975 respectively to 3% and 4% in 1976 and 1977 respectively. Spoilage of 35% was in a small lot of *P. indicus*. The reduction in spoilage during 1976 and 1977 was owing to the payment of the processors to good quality material only and consequent care on the part of the suppliers who started sorting of spoiled prawns at landing centres.

Table 2 shows the percentage weight of the discoloured material. It is clear that discoloured material was more in *P. stylifera* except for 17% in *M. dobsoni* in 1975.

Table 1. *Combined species-wise spoilage of prawns in P. P. C. and factories*

Year	<i>M. dobsoni</i> %	<i>P. styliifera</i> %	<i>P. indicus</i> %	Total %	Observations	P. P. C/ Factories
1974	0-12.5	0-12.5	0- 4.5	0-12.5	19	5
1975	0-12.0	0	0-35.0	0-35.0	40	15
1976	0- 3.0	0	0	0- 3.0	57	17
1977	0- 0.5	0-4.0	0	0- 4.0	65	17

Table 2. *Discoloured material observed in P. P. C. and factories*

Year	<i>M. dobsoni</i> %	<i>P. styliifera</i> %	<i>P. indicus</i> %	Total %	Observations	P. P. C/ Factories
1974	0-11	0-12	0- 7	0-12	19	5
1975	0-17	0-12	0-10	0-17	40	15
1976	0- 6	0-11	0-10	0-11	57	17
1977	0- 4	0- 8	0- 5	0- 8	65	17

Table 3a. *Mean yield (%) and 95% confidence interval of the size grades recovered from 300 and 400 counts/kg of whole prawns on peeling*

Species	No. of lots observed	Count per kg	Size grades recovered per pound	Mean yield %	Standard error	95% confidence interval for the mean
<i>M. dobsoni</i>	19	300	130/200	40.9	2.46	3.57-46.1
			200/300	31.8	1.87	27.9-35.7
			300/500	20.7	2.39	15.7-25.8
			Broken	6.5	0.81	4.8- 8.2
<i>M. dobsoni</i>	17	400	130/200	10.5	1.21	7.9-13.1
			200/300	38.3	1.49	35.1-41.5
			300/500	39.9	2.13	35.3-44.4
			Broken	11.3	1.43	8.3-14.3
<i>P. styliifera</i>	16	300	130/200	31.9	3.34	24.7-39.0
			200/300	44.3	2.67	38.7-50.0
			300/500	18.9	3.67	11.1-26.7
			Broken	4.9	0.87	3.0-6.7
<i>P. styliifera</i>	16	400	130/200	13.8	1.38	10.9-16.8
			200/300	31.7	2.55	26.3-37.1
			300/500	45.7	2.40	40.6-50.8
			Broken	8.7	0.78	7.1-10.4

Table 3b. Mean yield and 95% confidence interval for size grades recovered from 200, 250, 300, 350, 400, 450 and 500 counts per kg of whole prawns (cooked and peeled)

Species	No. of lots observed	Count per kg	Size grades recovered per pound	Mean yield %	Standard error	95% confidence interval for the mean
<i>M. dobsoni</i>	10	200	100/200	30.0	8.47	11.2-48.9
			130/300	55.5	7.27	39.3-71.7
			300/500	8.1	3.67	...
			Broken	9.6	3.52	1.7-17.5
-do-	21	250	130/300	57.1	1.97	53.0-61.2
			300/500	29.3	2.69	23.7-34.9
			500up	4.3	1.50	1.2-7.4
			Broken	8.4	0.79	6.8-10.2
-do-	17	300	130/300	40.1	3.27	33.2-47.0
			300/500	33.3	3.68	25.5-41.1
			500 up	14.4	2.95	8.1-20.7
			Broken	12.5	0.99	10.4-14.6
-do-	10	350	130/300	28.4	3.85	19.7-37.1
			300/500	32.5	4.89	21.4-43.6
			500 up	23.6	3.40	15.9-31.3
			Broken	16.4	2.26	11.3-21.5
-do-	19	400	130/300	19.8	2.44	14.7-24.9
			300/500	37.3	2.54	32.0-42.6
			500 up	29.1	2.73	23.4-34.8
			Broken	13.3	3.21	6.6-20.0
-do-	7	450	130/300	8.6	0.62	7.1-10.1
			300/500	35.1	3.11	27.5-42.7
			500 up	37.9	2.61	31.5-44.3
			Broken	18.3	1.55	14.5-22.1
-do-	7	500	130/300	4.1	1.18	1.2- 7.0
			300/500	35.5	3.99	25.8-45.2
			500 up	36.8	4.39	26.1-47.5
			Broken	23.5	3.13	15.8-31.2
<i>P. styliifera</i>	7	200	100/200	19.8	2.66	13.3-26.3
			130/300	34.5	4.88	22.6-46.4
			300/500	35.9	2.49	29.8-42.0
			Broken	8.0	1.79	3.6-12.4
-do-	20	250	100/200	16.4	2.31	11.6-21.2
			130/300	28.9	1.85	25.0-32.8
			300/500	41.9	2.74	36.2-47.6
			500 up	5.4	2.01	1.2- 9.6
			Broken	9.3	0.80	7.6-11.0
-do-	16	300	100/200	4.2	1.55	0.9-7.5
			130/300	23.0	1.60	19.6-26.4
			300/500	55.9	3.38	48.7-63.1
			500 up	6.0	1.29	3.3- 8.7
			Broken	11.8	0.97	9.7-13.9

Table 3b. (Contd.)

Species	No. of lots observed	Count per kg	Size grades recovered per pound	Mean yield %	Standard error	95% confidence interval for the mean
<i>P. styliifera</i>	21	350	100/200	1.7	0.65	0.4- 3.0
			130/300	17.7	1.74	14.1-21.3
			300/500	55.1	2.54	49.8-60.4
			500 up	13.1	1.35	10.3-15.9
			Broken	12.2	0.75	10.6-13.8
-do-	12	400	100/200	2.1	0.93	0-4.2
			130/300	14.1	2.10	9.5-18.7
			300/500	47.2	2.93	40.8-53.6
			500 up	20.7	1.36	17.7-23.7
			Broken	15.6	1.23	12.9-18.3

Table 4. Counts of whole prawns required in a specified size grade

Size grade required per pound	Count of whole prawns to be used per kg	Species	Expected % yield in the specified size grade
(a) Peeled			
130/200	300	<i>M. dobsoni</i>	41
130/200	300	<i>P. styliifera</i>	30
200/300	300	<i>P. styliifera</i>	43
200/300	400	<i>M. dobsoni</i>	38
200/300	300	<i>M. dobsoni</i>	32
200/300	400	<i>P. styliifera</i>	32
300/500	400	<i>P. styliifera</i>	46
300/500	400	<i>M. dobsoni</i>	40
(b) Cooked and peeled			
130/300	200 to 250	<i>M. dobsoni</i>	56 to 57
130/300	300	<i>M. dobsoni</i>	40
130/300	200	<i>P. styliifera</i>	35
130/300	250	<i>P. styliifera</i>	29
130/300	350	<i>M. dobsoni</i>	28
130/300	300	<i>P. styliifera</i>	23
300/500	300 to 350	<i>P. styliifera</i>	55 to 56
300/500	400	<i>P. styliifera</i>	47
300/500	250	<i>P. styliifera</i>	42
300/500	300 to 500	<i>M. dobsoni</i>	33 to 37
300/500	200	<i>P. styliifera</i>	36
300/500	250	<i>M. dobsoni</i>	29
500 up or 400/600	450 to 500	<i>M. dobsoni</i>	37 to 38
500 up or 400/600	400	<i>M. dobsoni</i>	29
500 up or 400/600	350	<i>M. dobsoni</i>	24
500 up or 400/600	400	<i>P. styliifera</i>	21

No data on *P. styliifera* for counts above 400

Table 3a and 3b give the mean yield in different size grades for a particular count of the whole prawns, 95% confidence interval and standard error for the means. Table 3a presents the figures for peeled prawns and 3b for cooked and peeled. The rate of recovery varied for the two species. For peeled 300 and 400 counts per kg and for cooked and peeled 200, 250, 300, 350, 400, 450 and 500 per kg were used.

Differences in the recovery rate for each size grade and between two species of the same count were examined by t-test. Significant differences were observed with respect to size grades. The differences in the recovery rates of the same species of different counts were studied by t-test and analysis of variance (when the counts exceeded 2.) The differences between counts were found significant.

Table 4 is based on the yields presented in Table 3a and 3b and the results of the tests for significance. The counts for cooked and peeled were grouped on the basis of 'test for comparison among means' as described by Snedecor (1961).

The 'count' refers to number per kg which indirectly specifies the average size of prawns in the lot. But, if the size variability of prawns differs among lots of the same count, it may cause variations in the yield in the same size grades obtained from different lots having the same counts. Variation in rate of recovery among the same species was found to be caused by the differences in the method of peeling.

The authors are grateful to the processors and owners of primary processing centres, Cochin for their co-operation. They are thankful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology, Cochin for encouragement and permission to publish the paper and to Dr. P. N. Kaul for valuable suggestions.

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Studies on the Influence of Moisture and Specific Gravity on the Strength Properties of Mango Wood (*Mangifera indica*)

N. UNNIKRISHNAN NAIR, K. RAVINDRAN and A. G. GOPALAKRISHNA PILLAI

Central Institute of Fisheries Technology, Cochin-682 029

Influence of moisture and specific gravity on the strength of mango wood is discussed. The co-efficient of correlation between specific gravity and breaking strength was found to be nonsignificant. The relation of strength and moisture was found to be highly significant. The mean strength values indicated a reduction in strength when the moisture increased from 8.5 to 18.8%. However no appreciable difference in strength values could be observed when moisture increased above 37%. The strength-moisture relationship is a straight line, passing approximately through the fibre saturation point. By using the exponential formula, the breaking strength corresponding to any moisture level between zero and fibre saturation can be determined.

Timber is a versatile construction material. It has the ability to resist applied forces. The strength of wood depends on various mechanical properties of the wood and it varies from species to species. A basic knowledge of the strength properties of wood is therefore an essential pre-requisite, if timber is to be used in an economical and efficient manner. Extensive studies on the strength properties of 125 native grown and imported soft woods have been conducted by the Forest Products Research Laboratory (Armstrong, 1953). Of late, studies on arsenical creosote (Nair *et al.*, 1972 a, b) for marine structures have shown that secondary species of wood like Mango and Haldu are susceptible to preservative treatment which enhances the life of these timbers. The response of *Mangifera indica* to preservative treatment prompted a detailed study into other basic knowledge of its strength properties. Small differences in moisture content and specific gravity are known to influence the strength properties of timber (Armstrong, 1953). From many points of view a series of methodical laboratory tests are preferred to actual conditions of service as it is economical with reference to material and time and also simplification and standardisation of test procedure. The strength property studies would provide a basis for assessing the utilisation values of this

home grown timber, particularly for fishing boat construction.

Materials and Methods

Seasoned mango test panels of size 15 X 4 X 0.6 cm with a central bore of 2 cm diameter were prepared for static bending strength studies. Known moisture concentrations, namely, 8.5, 10, 18.8, 37, 42.2, 58, 69, 81, 90 & 98% were maintained in desi-

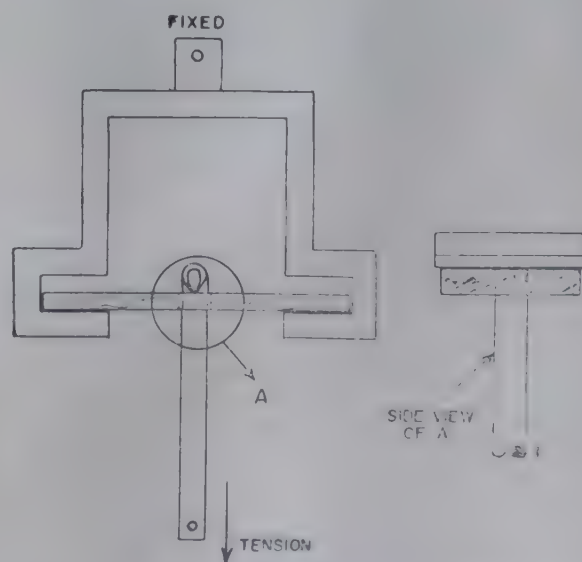


Fig. 1. Arrangement for determining the static bending strength of the wooden panels

cators by preparing solutions of zinc chloride, potassium chloride, ammonium sulphate, zinc sulphate and copper sulphate. Static bending strength of each panel was determined in a tester. A special test rig to hold the panels was designed and fitted to the tester as shown in Fig. 1. The panels were divided into ten different groups, each group consisting of five panels of identical moisture content. The mean values of specific gravity, weight, moisture and breaking strength of the panels under different groups are presented in Table 1.

Table 1. Mean values of specific gravity, weight, moisture and breaking strength of the panels

Groups	Specific gravity	Weight of panel g	Moisture content %	Breaking strength kg
1	0.560	27.003	8.5	62.10
2	0.586	28.240	10.0	45.50
3	0.581	27.976	18.8	40.40
4	0.557	26.848	37.0	37.60
5	0.581	28.022	47.2	38.60
6	0.582	27.817	58.0	35.00
7	0.590	28.439	69.0	34.80
8	0.696	35.072	81.0	27.00
9	0.556	26.808	90.0	28.40
10	0.562	27.066	98.0	27.05

The data were analysed statistically to determine the specific gravity — breaking strength and moisture—strength relationships. The mean specific gravity was observed to be 0.586 with standard deviation of 0.069 and the mean breaking strength was calculated as 37.62 with SD=13.74.

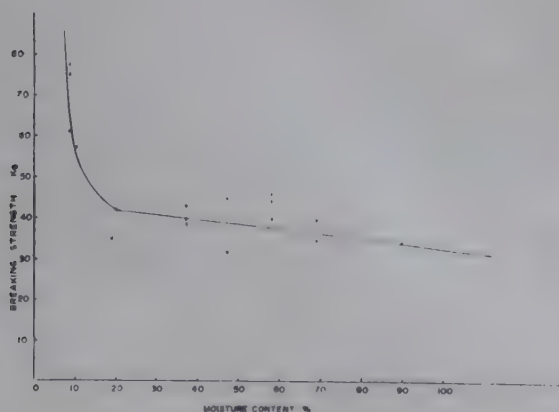


Fig. 2. Relation of breaking strength to moisture content

The correlation co-efficient, an expression for the closeness of the relationships between specific gravity—breaking strength and between moisture content—breaking strength was calculated using the formula

$$r = \frac{\sum Xy}{\sum X \sum y}, \quad \sum X, \sum y \text{ are standard deviations of } x, y \text{ respectively.}$$

Results and Discussion

The co-efficient of correlation between specific gravity and breaking strength was found to be $C=-0.07$ (non-significant at 5% level). Normally, specific gravity—strength relations are positive and significant. But in the present study, specific gravity had no influence over the strength properties. This may be due to the fact that the type of wood and the actual wood substance employed in the study were the same (Mean specific gra-

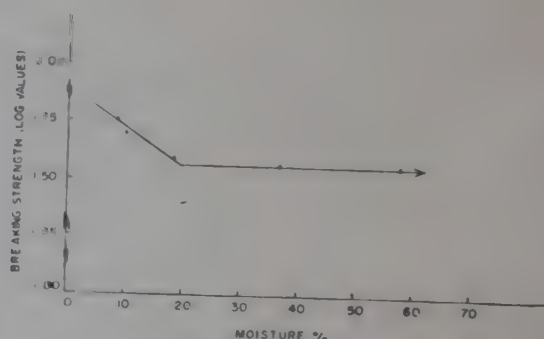


Fig. 3. Relation of breaking strength (log) to moisture percentage.

vity 0.586 and SD=0.069). The relation of strength and moisture appears to be highly significant. The co-efficient of correlation in this case was found to be -0.87 (significant at 1% level). The mean strength values clearly indicate that, when there is an increase in moisture content from 8.5% to

Table 2. ANOVA of group 1

Source of variations	SS	df	mS	F
Between groups	1364.91	2	682.46	*
Error	2143.38	13	164.80	
TSS	3508.30	15		

*Significance at 5% level

18.8% (Fig. 2), there is corresponding decrease in strength. No appreciable difference in strength values could be observed when moisture increased above 37%. The panels in groups 1, 2, 3 and in groups 4–10 were statistically tested separately to find out the significant differences if any between the means. The results are presented in Tables 2 and 3.

Table 3. ANOVA of group 2

Source of variation	SS	df	mS	F
Between groups	783.8982	6	130.65	15
Error	2366.458	27	87.66	
Total	3150.3562	33		

As the mean breaking strength of groups having moisture content 37.0% and above do not differ significantly, it is assumed to represent a straight line. The regression equation to this line was found to be $y = 47.002 - 0.207x$, by plotting the moisture content on the X axis and strength on Y axis. The inclined line representing the groups 1, 2, 3 and the straight line representing groups 4–10 intersect at the point 20, which can be the fibre saturation point (Fig. 2). This means that as the moisture content decreases from 20%, the breaking strength increases, but as the moisture increases above 20% there is no apparent increase in breaking strength. The corresponding breaking strength is noted to be around 42.

Studies conducted by Wilson (1932) have shown that the strength values between zero moisture and fibre saturation point can

be represented by an exponential formula, $\log S + \log Sp = K (Mp - M)$, where S is the strength corresponding to the moisture content, M, Sp and Mp are the strength and moisture content at the intersection point, K being a constant. In the present experiment Sp was found to be 42 and corresponding Mp was 20. In Fig. 3, the values of breaking strength with the corresponding moisture levels are plotted on a semi-logarithmic paper, with the moisture on the uniformly divided scale and strength on a logarithmically divided scale. As is observed from Fig. 3, the strength-moisture relationship is a straight line, passing approximately through the fibre saturation point. The inclined line also passes through the point at which 'M' is 8.5 and 'S' 62.1. Substituting the respective values, K was found to be 0.015. By using the values of K, Mp and Sp the breaking strength corresponding to any moisture level between zero and fibre saturation can be determined.

The authors are grateful to Shri G. R. Unnithan, Scientist for the help in the statistical treatment of the data. They are indebted to Shri R. Balasubramanyan, Head, Craft & Gear Materials Division, for encouragement and Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology, Cochin for permission to publish the paper.

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Investigations on Long Distance Transportation of Fish-V, Transportation of Filleted and Round Seer Fish (*Scomberomorus* sp.) from Kakinada to Calcutta by Rail

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Iced seer fish (*Scomberomorus* sp.) was transported by rail in expanded polystyrene-insulated plywood boxes from Kakinada to Calcutta in round and fillet forms. While both withstood the rigours of transportation squarely, the fillets fetched only half the price of round fish in the auction conducted at the Calcutta market.

A detailed comparative study of the insulation efficiencies of 25.4 mm thick expanded polystyrene slab and double and quadruple layer jute fabric, all sealed in 150 gauge polythene sheets, when employed for transportation of several varieties of iced marine and brackish water fishes in second hand teachests by rail over long distances (about 1000 km—journey time: 40 h approx.) has been reported in the last communication of this series (Rao *et al.*, 1978). The comparative amenability of one particular variety of fish, namely, seer (*Scomberomorus* sp.) in round and fillet forms to transportation in 25.4 mm thick expanded polystyrene-insulated plywood boxes from Kakinada to Calcutta and their consumer appeal in the Calcutta market in terms of their auction sale values form the subject matter of the present study.

Materials and Methods

Freshly landed seer fish from gill net catches at Kakinada were procured and transported immediately to the laboratory. They were washed and the flesh flayed off with a sharp knife from both sides of the backbone. The knife was driven down to the vertebral column transversely about one cm below the gill slit. The cutting edge was

then directed towards the caudal region and moved grazing the backbone so that maximum possible amount of edible matter was severed in one piece from one side of the skeleton. This was subsequently cut transversely into 2 or 3 pieces depending upon the size of the fish. The fillets were then washed free of blood, adhering fragments of entrails if any, loose hanging pieces of flesh and any extraneous matter. In the case of transportation in round form, the fish were washed clean and used as such. Packing, transportation and assessment of quality were carried out as described in the earlier communication (Rao *et al.*, 1978). After drawal of samples for analysis, the transported fish were sold in public auction through a public undertaking at Calcutta.

Results and Discussion

Number of experiments performed, quantity of fish used, results of analyses at both the despatching and receiving centres and auction at the latter centre are summarised in Table 1.

The fish samples were of excellent quality at the despatching centre, but the bacterial loads and TVN values were comparatively more in the fillets than in the round fish. These are to be expected since filleting exposes large areas of the flesh which readily take up bacterial contamination

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Table 1. *Analytical results and auction rates of whole and filleted seer fish*

Particulars	Despatching centre		Receiving centre	
	Whole	Fillets	Whole	Fillets
Number of experiments	12	6	12	6
Weight of fish (kg)	917	105	917	105
Total bacterial count/g	3.8178	4.7326	4.9347	4.7928
(mean log values)	(0.277)	(0.375)	(0.686)	(0.218)
Total volatile nitrogen	10.15	15.8	16.88	20.65
mg/100 g (mean)	(1.7260)	(2.1863)	(4.3187)	(1.8436)
Organoleptic quality	Good	Good	Fair	Fair
Auction sale rate Rs./kg (mean)			1.88	0.86
			(0.5757)	(0.4620)

Figures in parentheses are standard deviations

from the washing water, holding utensils, table and other surfaces with which they come into contact, accompanied by consequent release of small quantities of volatile bases. This is in close analogy with the state of affairs obtaining in the prawn processing industry, where the peeled and deveined prawns which have got their entire flesh exposed, exhibit considerably higher bacterial counts than headless prawns, where only the cut ends at the head regions are exposed. At the receiving centre, the increase in total bacterial count of the round fish is significant, slightly above one log value, while the fillets do not exhibit any increase at all. This may be due to the initial bacterial loads in the intestines and gills of the round fish gradually proliferating during the transit period at both ends and in the train and finding access into the flesh, while such a contingency does not arise in the case of fillets. Being much thinner than round fish, quicker cooling takes place in fillets in contact with the crushed ice, which retards bacterial multiplication. Both round fish and fillets show almost the same bacterial loads at the receiving centre. TVN values in both round fish and fillets show reasonable increases; but not significant enough to indicate any appreciable degree of spoilage. From these as well as the organoleptic observations recorded, it can be concluded that both round and filleted seer fish withstand the transportation squarely, arriving at the

destination in comparably good state of preservation.

However, the most striking difference is observed in the case of auction of the above forms at the Calcutta market, fillets being sold at less than half the price of round fish. Considering the fact that approximately 50% filleting losses occur due to elimination of heads, entrails and vertebral columns, one kg of fillet at the receiving end is equivalent to 2 kg of round fish. Hence the price realisation in the case of fillets in effect is only 25% of that of the round fish.

It is a known fact that top preference in the Calcutta market is always for fresh water fishes, followed by brackish water and marine fishes in the order. This has been amply borne out by earlier experiments conducted under the All India Co-ordinated Research Project on Transportation of Fresh Fish. While fresh water fishes like catla, rohu and silver carp netted sale values upto Rs. 12.41/kg, brackish water varieties like chanos and mullet could fetch only a maximum of Rs. 7/kg, average value lying between Rs. 3 and Rs. 4/kg and marine fishes were sold for even as low as 40–50 ps/kg (Anon, 1977, 1978). The present study shows that filleted fish command comparatively poorer demand at Calcutta than the same species in round form. From the points of view of scientific principles and

economy in transportation expenses, filleting has to be advocated, since in the first place this step removes all the carriers of micro-organisms like gills and intestines, which are all unwanted materials, thereby preventing entry of the organisms from this source into the edible flesh. The digestive enzymes, present in the entrails are also eliminated reducing the danger of their attacking the fish muscle. Secondly, filleting gets rid of other unwanted parts like heads and skeletons, thus concentrating the edible material in bulk, facilitating handling and transportation as well as effecting economy in the freight charges due to the following reasons: (1) It is more convenient and easy to pack fillets than round fish because of their shapes and dimensions. (2) Quantity of ice required to pack the fillets is about 50% of that required for round fish because of the reduction in volume of the material. (3) In fillet form, material equivalent to more than double their weight of round fish can be packed in the same size of container due to the same reasons as in (2). (4) Weight to weight more edible material is carried for the same freight in the fillet form. (5) Ultimate savings in transportation charges are considerable. However, this study shows that

the consumers' acceptance/aesthetic sense is to be given preferential consideration than scientific principles or economy of transportation from the traders' point of view.

The authors wish to record their thankfulness to S/Shri G. K. Kuriyan and M. R. Nair, Director and Project Co-ordinator respectively of the Central Institute of Fisheries Technology, Cochin, for kind permission to publish these results. They are also grateful to Shri G. R. Unnithan, Scientist at the above Institute for statistical analysis of the results.

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Studies on the Growth Temperature Ranges of Bacteria Isolated from Fresh Sardine at Different Primary Incubation Temperatures

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The effect of primary incubation temperature on the growth temperature range was studied with reference to 296 bacterial cultures isolated from sardine using streak plate technique. The primary incubation temperature used during bacteriological sampling caused a selection of strains according to their growth temperature requirements. Incubation at 8°C caused greater recoveries of psychrotrophs while 37°C favoured mesophiles. An incubation temperature of 30°C facilitated the growth of both psychrotrophs and mesophiles.

Temperature is an important environmental factor which affects the growth and development of micro-organisms (Hanus & Morita, 1968). Bacteria have an optimum growth temperature and growth above or below this temperature may cause changes in the physiological and metabolic activities (Ingraham & Bailey, 1959). The psychrophilic bacteria which prefer low temperature have an optimum temperature between 10°C and 20°C, mesophiles 30°C and 40°C and thermophiles 50°C and 65°C. However these groups have no sharply distinguished boundaries between them and are somewhat hazy. Moreover the cardinal points are also affected by other factors such as supply of nutrients, pH of the medium and products of metabolism (Rose, 1968; Upadhyay & Stokes, 1963).

Fresh fish carrying as it does a heterogeneous population of all these types of bacteria presents an interesting material for study. Part of the natural flora associated with marine environment and fish is psychrophilic or psychrotrophic. The latter has a very wide growth temperature range while the former has a restricted temperature range from 0°C to 20°C. The fish caught from tropical areas may carry mesophilic terrestrial types as well. The percentage of these different types may vary with season; mesophiles predominate during warmer months while in winter biochemically less active groups are encountered (Karthiayani & Iyer, 1971 a). The incubation temperature used

for the primary isolation of bacteria from fish samples causes a selection of strains based on biochemical characteristics within the species or from among the various genera (Karthiayani & Iyer, 1971 b). It may also effect a selection of strains based on their growth temperature ranges. Hence this investigation was undertaken to study the growth temperature ranges of micro-organisms associated with fresh marine fish and also to gain an insight into the appropriate incubation temperature needed during bacteriological examination of fresh uniced fish, since such a temperature is likely to facilitate maximum recoveries of bacteria from the sample being examined.

Materials and Methods

Fresh sardines (*Sardinella longiceps*) landed by local country crafts at Cochin were brought to the laboratory in sterile bottles and sampled immediately. The duration between procurement of fish and its examination in the laboratory never exceeded two hours. While sea water agar (SWA) and nutrient agar (NA) were employed for the primary isolation of the cultures, their growth temperature studies were carried out in sea water peptone (SWP) and nutrient broth (NB). Micro-organisms were isolated by spread plating the diluted homogenates of the skin and muscle portion of the fish on SWA and NA. 0.5 ml of 10^3 or 10^4 dilution of the homogenate prepared by homogenizing 10 g of the

fish muscle with 90 ml of sterile sea water was spread on appropriate media using a bent glass rod. Duplicate plates were incubated at 8, 30 and 37°C for 21, 3 and 2 days respectively. After incubation, all the microbial colonies that developed on countable plates were picked and transferred to SWA or NA slants.

296 cultures were studied from July to April on an average of 30 cultures a month. The growth of each pure isolate was studied at a series of temperatures. A uniform and slightly turbid cell suspension in SWP or NB of the isolate was prepared. SWP was used for the cultures isolated from SWA and NB for those isolated from NA. About 0.05 ml of the culture suspension was inoculated into duplicate test tubes containing SWP and NB. The inoculated tubes were incubated at 0, 10, 20, 30, 37, 45 and 56°C. Simultaneously duplicate SWA and NA slants were also inoculated and incubated at the above temperatures. The time required for the appearance of growth was noted in each case and also the degree of growth on slants which was assessed by visual comparison. In addition to growth studies the cultures were also subjected to Gram staining.

Results and Discussion

The percentage of the microbial cultures that grew at different test temperatures is presented in Table 1. It is evident from the data that while all the cultures isolated from SWA at 37°C could grow well at the test

temperature of 30°C, only 50% of the cultures isolated using a primary incubation temperature of 30°C, could grow at the test temperature of 37°C. In nutrient agar, however, 66 % of the cultures isolated from 30°C plates could grow at 37°C. Irrespective of the media used, as the primary incubation temperature increased from 8 to 37°C, a reduction was noted in the number of cultures that could grow at the lower temperatures of 0 to 20°C. But at test temperatures of 30, 37 and 45°C, their number increased with increase in the primary incubation temperature. It is apparent that primary incubation at 8°C caused greater recoveries of psychrotrophs while 37°C favoured mesophiles. Thus the 30°C incubation can be considered as most suitable for the growth of both psychrotrophs and mesophiles.

The prevalence of different cultures with respect to their Gram reaction was also noted (Table 2). At all the three primary incubation temperatures and in the two media, Gram negative rods predominated, followed by Gram positive cocci and Gram positive rods. This was in accordance with the previous observations of Karthiayani & Iyer (1967), which revealed a high preponderance of Gram negative rods, mainly *Achromobacter*, *Vibrio* and *Pseudomonas* groups, on the skin and muscle of fresh sardines.

The effect of primary incubation was found to reflect on the secondary incubation temperatures also. Majority of the cultures

Table 1. Growth of bacteria at test temperatures

Media	Temperature of primary isolation °C	No. of cultures isolated	Percentage growth						
			0°C	10°C	20°C	30°C	37°C	45°C	56°C
Sea water agar	8	50	100	100	100	90	40	Nil	Nil
	30	60	37	37	70	100	50	20	Nil
	37	42	18	18	28	100	100	57	Nil
Nutrient agar	8	42	100	100	100	74	34	Nil	Nil
	30	60	34	34	60	100	66	26	Nil
	37	42	4	4	21	100	100	48	2
Total		296							

Table 2. *Types of bacteria isolated at the three primary incubation temperatures*

Type	Percentage of different types isolated from					
	NA			SWA		
	8°C	30°C	37°C	8°C	30°C	37°C
Gram positive cocci	7	8	17	10	16	12
Gram positive rods	4	5	7	2	2	7
Gram negative rods	89	87	76	88	82	81

Table 3. *Recovery of psychrophiles, psychrotrophs and mesophiles on SWA and NA at the three primary incubation temperatures*

Type	Percentage recovery					
	SWA			NA		
	8°C	30°C	37°C	8°C	30°C	37°C
Psychrophiles (0-20°C)	10	Nil	Nil	13	Nil	Nil
Psychrotrophs (0-37°C)	90	34	8	87	30	1
Mesophiles (20-45°C)	Nil	66	92	Nil	70	99

showed good growth at the initial isolation temperature, that is, majority of the cultures isolated at 8, 30 and 37°C had their maximum growth at 20, 30 and 37°C respectively. Another observation was that in plates initially incubated at 8°C, it required 12 to 14 days for the first appearance of colonies on the plates. Picked colonies could, however, grow well within 5 days when inoculated into the respective liquid or solid media and incubated at 8°C. With cultures isolated at primary incubation temperatures of 30 or 37°C, no such lag existed and growth, either in liquid media or solid agar took place within 24 h at the respective temperatures.

Thus the primary incubation temperature used in the bacteriological sampling caused a selection of strains according to

their growth temperature requirements. Organisms could be placed in psychrophilic (0-20°C), psychrotrophic (0-37°C) and mesophilic (0-45°C) groups (Table 3). Primary incubation at 8°C facilitated the recovery of psychrophiles (10-13%) and psychrotrophs (87-90%). When the primary incubation temperature was raised to 30°C, the percentage of the psychrotrophs decreased to 30-34%, while the mesophiles formed 66-70%. At 37°C, however, psychrotrophs were negligible (1-8%) but the mesophiles constituted 92-99% of the total.

According to the definition of Ingraham & Stokes (1959) and later by Morita (1975) those cultures which grow well at 0°C within a week's time and have a growth range from 0 to 30°C can be considered as psychrotrophs. But some of the psychro-

trophic cultures isolated by us grew well at 37°C. Higoshi *et al.* (1975) have reported the existence of psychrotrophic *Pseudomonas* in milk, whose maximum growth temperature ranged from 0 to 45°C or from 33 to 37°C. The ability of some psychrotrophs to grow at 37°C has been attributed to environmental factors such as available substrate, salinity, temperature and hydrostatic pressure (Morita, 1975). They can also be variants of original mesophiles which adapted to a lower temperature (Larkin & Stokes, 1966).

Between SWA and NA, the growth pattern was found to be almost similar. However it was seen that irrespective of the temperature of primary incubation, the number of cultures with growth temperature range of 0°C-37°C were slightly more in SWA than in NA. (Nirmala Thampuran—unpublished data).

Different incubation temperatures are recommended for the bacteriological examination of food. An incubation temperature of 37°C enhances the growth of mesophilic organism from meat and meat products. Roughley *et al.* (1974) recommend incubation at 30-32°C to include both psychrophiles and mesophiles. An incubation temperature of 20-25°C is used for cold tolerant bacteria from soil, water and foods (Clark, 1967), while a temperature as low as 1°C is suggested for psychrotrophic organisms from refrigerated food (Barnes & Impey, 1968). According to Nottingham *et al.* (1975) incubation of plates at 25 and 30°C gave similar counts, but the 37°C count was usually lower and more variable for aerobic bacteria, due to the inability to include psychrotrophs at this temperature. In raw milk, incubation at 20°C for 4 days is presumed to be superior to incubation at 35°C for 2 days to include both psychrotrophs and mesophiles (Higoshi & Hamada, 1975).

Our study indicates that in marine environment, psychrotrophs occur commonly and in appreciable numbers. Primary incubation temperature of 37°C will exclude some of these types. Lowering the incubation temperature to 30°C can however bring in both psychrotrophs and mesophiles.

The authors are grateful to Shri G. K. Kuriyan, Director of the Institute, for his keen interest and encouragement. They are also thankful to the technical staff of the laboratory for specimen collection and laboratory assistance.

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A New Large Mesh Trawl for Demersal Fishery

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A new large mesh demersal trawl of 32 m head rope length is found more efficient for the exploitation of demersal fishes off Veraval. Increased catch with a proportionate increase of demersal fishes was obtained when compared to a standard bottom trawl of 32 m head rope length with small meshes, suggesting the possibility of increasing the mesh size of trawl nets in the forepart. This increases the mouth area of net which enhances the fishing power by covering a large area per tow. The net is simple in construction, easy to repair and maintain and fewer in the number of meshes.

The utilisation of the fishery resources in the seas around India was concentrated until very recently to the inshore waters and the offshore region was left mostly unexploited. Surveys by the Government of India fishing vessels indicated the existence of substantial fishery resources in the offshore waters (Anon, 1972 a; Jayaraman *et al.*, 1959; Joseph, 1974; Rao *et al.*, 1966). The North West Coast extending from Ratnagiri to Kutch has the largest shelf area of about 200,000 km² and is well known for its rich demersal fishery resources. Of late, inshore shrimp trawlers are trying to venture to offshore waters for capturing demersal fishes as inshore shrimp trawling is becoming uneconomical. Suitable trawl gear and accessories have to be developed for offshore fishing as the inshore gear would not be suitable and effective for offshore waters. Introduction of large mesh demersal trawls is one of the recent advancements in offshore and deep sea trawling (Anon, 1974; Anon, 1975 a, b; Anon, 1977). Advantages of mid water and pelagic trawls have been reported by several workers (Anon, 1972 b; Anon, 1973; Johnson, 1971; Gorman, 1975; Rehme, 1973), but no attempt has been made in India with large mesh trawls. There is a general tendency to reduce the mesh size of trawls in India resulting in decreased catch per unit effort in inshore trawling. Trawl nets with less than 20 mm mesh in the codend and less than 50 mm mesh in the

forepart are common. This tendency must be discouraged from the trawl fisheries management point of view. Investigations with a new 32 m large mesh demersal trawl were carried out in the sea off Veraval, North West Coast of India and the results reported in this paper. Depths of 40 metres and beyond is treated as 'offshore' and less than 40 metres as 'inshore' in this study.

Materials and Methods

Investigations were conducted from December, 1977 to May, 1978 from boat Fishtech 8 having 15.2 m overall length fitted with 165 hp engine. The new trawl was used along with a 32 m long wing trawl described by Kartha (1976) for comparison. Details of the new trawl, is given in Figure 1 and Tables 1, 2 & 3. A comparative account of both the nets is given in Table 4. A pair of rectangular flat otter boards described by Kuriyan *et al.* (1964) was used. Double sweeps of 5 m in length of high density polyethylene twine of 18 mm diameter were kept in between net legs and otter boards for all the operations. Trawling speed was 2.5 knots per h at 1200 rpm of the engine for all the hauls. Ground, depth, warp, course and duration were also kept strictly comparable. Catch composition of important species of fish in each haul was recorded. Trawl warp tension was measured by the device described by Satyanarayana and Nair (1965). Horizontal opening between otter boards was measured and calculated by the method suggested by Benyami (1959) and

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Table 1. Details of the 32 m two seam large mesh trawl *

Webbing	A	A1	B	B1	C	C1	D	E	E1	F	G	H	I
Twin diameter mm	2.5	2.5	2.5	2.5	2.0	2.5	1.5	2.0	2.5	1.5	1.5	2.0	2.0 (double)
Breaking strength kg	63	63	63	63	45	63	36	45	63	36	36	45	45x2
Stretched mesh mm	150	150	150	150	120	150	100	100	150	60	40	30	30
Upper edge	24	1	24	1	219	180	195	187.5	130	166	150	133	133
Lower edge	60	24	45	24	163	175	100	100	125	100	100	133	133
Depth	80	12	123	12	47.5	5	95	87.5	5	66	50	150	75
Baiting rate													
Inner	1:1.8	1:1	1:1.2	1:1	...	...	...	...	...	...	...	...	...
Outer	1:1	1:1	1:1	1:1	1:1.7	1:2	1:2	1:2	1:2	1:2	1:2	...	...
Co-efficient of hanging	1.00	1.00	1.00	1.00	—	0.50	...	...	0.50	...	...	...	...
Hanging	$\frac{a}{A+AI}$	$\frac{13.75}{13.70}$	$\frac{d}{B+B1}$	$\frac{20.25}{20.25}$	—	$\frac{b}{C1} = \frac{4.5}{9.0}$	—	—	$\frac{c}{E1} = \frac{3.0}{6.0}$	—	—	—	—

* Blue, high density polyethylene with single trawl knots.

Total weight of net 75 kg

Table 2. *Details of lines and ropes**

Material	a	b	c	d	e	f
		High density polyethylene				
Diameter mm	18	18	18	18	18	18
Breaking strength kg	3460	3460	3460	3460	3460	3460
Length m	13.75	4.50	3.0	20.25	5.0	5.0

*Head rope 32 m, foot rope 43.5 m

Table 3. *Details of floats, sinkers and otter boards*

	Floats	Sinkers	Otter boards
Number	21		2
Material	plastic	iron	iron and wood
Shape	spherical	link chain	rectangular flat
Diameter mm	150	6	—
Length mm	—	—	1524
Breadth mm	—	—	762
Static buoyancy kg	1.550	—	—
Weight in air kg	0.300	40.0	100.0

Table 4. *Comparative design details of the two nets*

Particulars	32 m long wing trawl	32 m large mesh demersal trawl
Mesh size mm		
Wings	60	150
	50	
Body	50	150
	40	120
	30	100
		60
		40
Codend	25	30
Total meshes	2,06,675	1,41,900
Twine size mm		
Wings	1.5	2.5
Body	1.5	2.0
		1.5
Codend	1.5 double	2.0
		2.0 double
Weight of webbings kg	27.0	51.0
Type	Light duty, four seam and overhang	Heavy duty, two seam, overhang and high rise
Length of head rope m	32.0	32.0
Length of foot rope m	37.0	43.5
Length of wing m	14.75 (upper)	13.75 (upper)
	17.25 (lower)	20.25 (lower)
Size of rope	18 mm dia. polyethylene	18 mm dia. polyethylene
Floats	Hard plastic—17 Nos. 15 cm dia. 1550 g extra buoyancy	21 Nos. 15 cm dia. 1550 g extra buoyancy
Chain	Iron link chain 6 mm dia. 33 kg	Iron link chain 6 mm dia. 40 kg

Table 5. *Results of comparative fishing with 32 m long wing trawl and 32 m large mesh demersal trawl*

Particulars		32 m long wing trawl	32 m large mesh demersal trawl
Depth of operation m		27-58	27-58
Number of days		38	38
Number of hauls		50	50
Duration h		50	50
Trawl warp tension kg	Average	542	584
	Range	436-632	506-684
Horizontal opening at otter boards m	Average	28.18 (54.19 %)	27.35 (52.54 %)
	Range	22.92-33.5 (44.00 %-64.40 %)	22.38-31.75 (43.00 %-61.00 %)
Catch kg	Total	2077.800	4791.750
	Catch per unit effort kg/h	41.555	95.835
	Range	6.000-176.500	9.500-451.000

Deshpande (1960). Percentage of horizontal opening was calculated from the total head line length (52 m) which included length of head rope (32m), length of net legs (5m+5m) and sweeps (5m+5m).

Results and Discussion

During 38 days, 50 comparative hauls were made (Table 5) of which 27 were at 40 to 58m in depths ('offshore') and 23 in 27 to 39m depths ('inshore'). Results obtained in 'offshore' and 'inshore' waters were tabulated (Table 6). Catch with respect to 'offshore' and 'inshore' waters is presented in Table 7.

From Tables 5, 6 and 7 it is evident that the large mesh trawl is very efficient for demersal fishes in the 'offshore' and 'inshore' waters. The increase in catch per unit effort of the new net was found to be 1.71 times (171 per cent) in the 'offshore' and 0.87 times (87 per cent) in the 'inshore' waters compared to small meshed net. The new net has 3 times bigger mesh (Table 4) in the forepart than that of the conventional net. Tables 6 and 7 show that the large meshed

net is more efficient in the 'offshore' waters than in the 'inshore' and is highly selective in catching quality fishes like perches, eel, seer and ghol that abound in offshore waters. With regard to fishes like *Lactarius*, elasmobranchs, sciaenids and miscellaneous varieties (Table 7) the new net was found superior in capturing all the demersal species, cephalopods and crustaceans. This is true with respect to inshore waters (Table 7), although slight variations have been observed due to random catches.

From the increased catch of high swimming and fast moving fishes like seer, eel, perches, ghol, silver bar etc., and bottom dwellers like lobsters, prawns, elasmobranchs, and flat fishes, the new net was highly efficient for bottom dwellers and high swimming fishes besides other demersal species like *Lactarius*, sciaenids, cephalopods and ribbon fishes. Thus the large meshed net had an overall versatility for capturing all the demersal species including smaller and miscellaneous varieties. The escape of fishes through the large meshes in the forepart of the net was insignificant. It was also noticed that only high swimming and

Table 6. *Results of comparative fishing with 32 m long wing trawl and 32 m large mesh demersal trawl in depth of 40 m, above and below*

Particulars	40 m and above (40-58 m)		Below 40 m (27-39 m)	
	32 m long wing trawl	32 m large mesh demersal trawl	32 m long wing trawl	32 m large mesh demersal trawl
Number of hauls	27	27	23	23
Duration h	27	27	23	23
Trawl warp tension kg	Average 549 Range 436-632	27 605 530-684	535 459-605	563 506-658
Horizontal opening at otter boards m	Average 30.12(57.93%) Range 26.44-33.50 (50.80%-64.40%)	28.88 (55.51%) 26.04-31.75 (50.00%-61.00%)	26.24 (50.45%) 22.92-30.35 (44.00%-58.40%)	25.78 (49.57%) 22.38-29.80 (43.00%-57.30%)
Catch kg/h	Total 1066.350 Catch per unit effort 39.500 Range 6-120	2891.100 107.100 18-451	1011.450 44.000 6.5-176.5	1900.650 82.620 9.5-372

Table 7. *Catch composition of 32 m long wing trawl and 32 m large mesh demersal trawl at depths of 40-58m and 27-39m*

Name of fish	40-58 m				27-39 m			
	32 m long wing trawl		32 m large mesh demersal trawl		32 m long wing trawl		32 m large mesh demersal trawl	
	Weight kg	%	Weight kg	%	Weight kg	%	Weight kg	%
Perches	7.40	4.0	180.10	96.0	5.70	79.0	1.50	21.0
Ghol	0.00	0.0	25.00	100.0	0.00	0.0	0.00	0.0
Eel	0.00	0.0	45.50	100.0	0.00	0.0	0.00	0.0
Seer	1.50	5.0	28.50	95.0	0.00	0.0	0.00	0.0
Pomfret	11.70	63.0	7.00	37.0	0.00	0.0	0.00	0.0
Silver bar	41.25	55.0	33.90	45.0	5.50	46.0	6.50	54.0
Ribbon fish	197.10	68.0	90.70	32.0	82.25	45.0	100.75	55.0
<i>Lactarius</i>	119.00	36.0	215.50	64.0	366.00	30.0	866.00	70.0
Elasmobranchs	0.50	0.8	69.25	99.2	*98.00	100.00	0.00	0.0
Cephalopods	127.00	33.0	254.00	67.0	34.50	45.0	42.00	55.0
Prawns & lobsters	0.90	5.0	16.65	95.0	2.50	25.0	7.40	75.0
Sciaenids	0.00	0.0	71.00	100.00	70.00	22.0	250.00	78.0
Miscellaneous	560.00	23.0	1854.00	77.0	347.00	36.0	626.50	64.0
Total	1066.35	27.0	2891.10	73.0	1011.45	35.0	1900.65	65.0

* Single big skate

Table 8. *Analysis of variance of fish caught*

Source	ss	df	mss
Total	8.43826	53	
Between gears	2.79830	1	2.7983***
Between days	3.91557	26	0.1506*
Error	1.72439	26	0.06632
Mean catch in terms of logarithms:			
32 m long wing trawl ...			1.4658
32 m large mesh demersal trawl ...			1.6934

* Significant at 5 % level
***Significant at 0.1 % level

Table 9. *Analysis of variance of horizontal opening at otter boards*

Source	ss	df	mss
Total	140.583	53	
Between gears	21.092	1	21.09200***
Between days	90.472	26	3.47969**
Error	29.019	26	1.11613
Average horizontal opening:			
32 m long wing trawl ...			30.1293
32 m large mesh demersal trawl ...			28.8793

** Significant at 1 % level
*** Significant at 0.1 % level

Table 10. *Analysis of variance of warp tension*

Source	ss	df	mss
Total	188,159.4896	53	
Between gears	41,944.8970	1	41,944.8970***
Between days	113,578.9896	26	4,368.4227**
Error	32,635.6030	26	1,255.2155
Average warp tension:			
32 m long wing trawl	...		549.2963
32 m large mesh demersal trawl	...		605.0370

** Significance at 1 % level
*** Significance at 0.1 % level

Table 11. *Analysis of variance of logarithm of fish caught*

Source	ss	df	mss
Total	8.05126	45	
Between gears	1.05035	1	1.05035***
Between days	5.50003	22	0.25000**
Error	1.50088	22	0.06822

Mean catches in terms of logarithms:

32 m long wing trawl	...	1.4432
32 m large mesh demersal trawl	...	1.7455

** Significant at 1 % level
*** Significant at 0.1 % level

Table 12. *Analysis of variance of horizontal opening at otter boards*

Source	ss	df	mss
Total	154.876	45	
Between gears	2.379	1	2.379 N.S.
Between days	131.034	22	5.95609***
Error	21.463	22	0.97559
Average horizontal opening:			
32 m long wing trawl	...		26.2422
32 m large mesh demersal trawl	...		25.7874

N. S. Not significant
*** Significant at 0.1 % level

Table 13. *Analysis of variance of warp tension*

Source	ss	df	mss
Total	76,772.3696	45	
Between gears	9,269.7609	1	9,269.7609**
Between days	45,867.8696	22	2,084.9031*
Error	21,634.7391	22	983.3972

Average warp tension:

32 m long wing trawl	...	535.0435
32 m large mesh demersal trawl	...	563.4348

* Significant at 5 % level
** Significant at 1 % level

fast moving fishes like seer and silver bar are gilled in the upper belly and flat fishes in the lower belly and none in wings and square of the new net. The escapement struggle of fishes may be more at the belly, throat and cod-end. Thus it seems that the reduction of mesh size at the forepart

of a trawl is quite unwarranted and instead a possible increase in mesh size at the forepart is more desirable.

The increased catch of high swimming fishes in the large meshed net indicates the high rising of its head line than that in the

conventional net. However this has not prevented the bottom contact as is evident from the catch of bottom dwellers. It may be noted from Tables 5 and 6 that the horizontal opening attained by the new net is slightly less than that of the conventional one, the total effective mouth area covered

larger trawls with wider mouths can effectively be operated in place of small meshed nets.

The average warp tension of the new net was slightly more (Tables 5 and 6) than that of the conventional net. This may be due to thicker twines, wider mouth area and increased water flow through the net. Weight of webbing can be brought down by reducing the twine size. However, minimum 2 mm diameter twine for the front portion and 1.5 mm diameter for the belly, throat and cod-end may be retained as the net is of a heavy duty purpose. Slackening of foot rope can be altered if desired. However, 25% increase in foot rope length over head rope length helps to maintain better bottom sweep when the net tend to rise high at the head line. The new net is simple to construct, easy to repair and fewer in the number of meshes. A 32 m long wing trawl has 2,06,675 meshes and a bulged belly trawl of 32 m head rope length 4,60,780 meshes, whereas the new net has only 1,41,900 meshes.

The analysis of variance for logarithm of fish caught, horizontal opening and warp tension for offshore is given in Tables 8, 9 and 10.

The difference between the mean catches is found to be very highly significant (Table 8). It appears that 32 m large mesh demersal trawl is more efficient than 32 m long wing trawl. The difference between the mean horizontal opening of the gears was highly significant (Table 9). The mean measurements show a larger average horizontal opening for the 32 m long wing trawl. Difference between the average warp tensions of the two gears was found very highly significant (Table 10). Average warp tension was more for 32 m large mesh trawl.

The analysis of variance for logarithm of fish caught, horizontal opening and warp tension for inshore waters are given in Tables 11, 12, and 13. The difference between the mean catches is very highly significant (Table 11). It appears that 32 m large mesh demersal trawl is more efficient than 32 m long wing trawl with reference to catch. The difference between the mean horizontal opening of the two gears was not significant

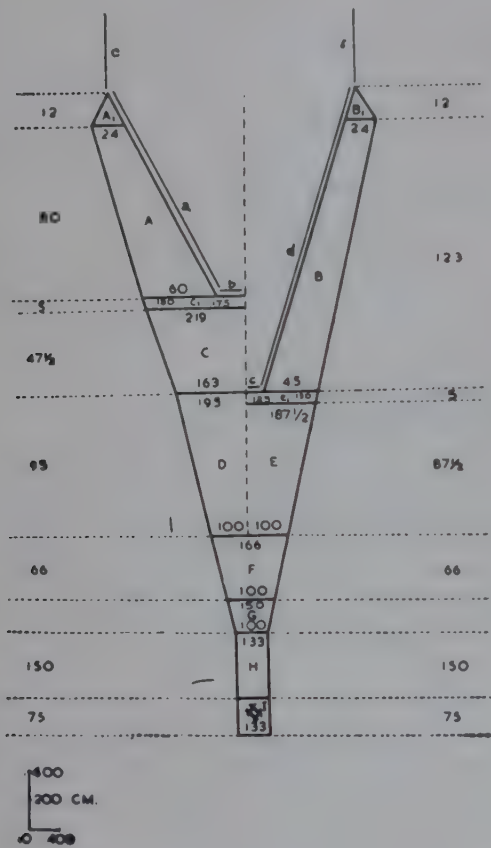


Fig. 1. 32m Large mesh demersal trawl

by the new net being much higher. This may be due to the increased high rising of the head line with a good bottom contact. Increased horizontal opening of the conventional net had no added advantage in the catching efficiency.

Increase of mesh size in the front portion results naturally in increased flow of water through the body of the net and less frightening effect on the fish. As the filtration is quick, fishes in the mouth area have to swim faster to escape which enhances the catching efficiency of the trawl. By increasing the mesh size in the front portion,

(Table 12), but that between average warp tension is highly significant (Table 13), the average tension being more in 32 m large mesh trawl.

The authors are grateful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology for encouragement, Shri R. Venkataraman, Scientist-in-charge, Veraval Research Centre for facilities and to Shri A. K. Kesavan Nair, Scientist for statistical treatment of the data and to Shri M. S. Fernando, Skipper and his crew for their co-operation.

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Smoke Curing of Mussels

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Substantial quantities of green mussels are available on the Kerala coast particularly from Calicut to north. But these are not properly exploited at present. Simple and economic methods of processing like drying and smoking can go a long way towards market promotion and better returns to the fishermen. This paper reports the method of preparation of smoked mussels which have a great potential for export as well as local marketing.

Large quantities of green mussels (*Perna viridis*) grow on the rocky structures of the sea coast of Kerala particularly from Calicut to north. But no reliable data are available on the annual collection of mussels in this region. Presently the mussels collected are consumed fresh in and around the locality. Consequently the fishermen get very poor returns, as people in far off places have no access to this delicious and nutritive commodity. The Central Institute of Fisheries Technology has developed a method of canning the mussels (Balachandran & Nair, 1975). Presently greater emphasis is laid on low cost technology and simple methods like drying and smoking, suitable for rural conditions, need greater attention. Dried and smoked mussels do have a great potential for export as well as for internal marketing. The paper presents the results of investigations carried out by the authors to prepare quality smoked product from mussels.

Materials and Methods

Fresh mussels collected from the rocky structures of the Korapuzha estuary, about 10 km north of Calicut, were employed in the study. Live mussels were washed in potable water and were given a "starvation treatment" as described by Balachandran and Nair (1975), followed by immersion in water chlorinated at 5 p. p. m. for 2 h, to reduce the sand content in the meat to an acceptable minimum level. The live meat was then shucked, washed well, to remove all extraneous matter. The meat was blanched in 5% brine (750 ml brine for every kg of meat). After 5 min blanching in boiling brine, the meat was drained well

and partially dried in an artificial dryer to a moisture level of 40-45% and smoked at 80-90°C for 30 min in a conventional vertical smoke kiln, in which smoke is generated by burning coconut husk and saw dust. The smoked product was finally dried in the dryer to a moisture level of about 10%. Estimations of moisture, sodium chloride, total nitrogen, ash and acid insolubles were conducted according to the AOAC methods (1960). Glycogen was estimated by the method of Van de Kleiy (1951).

Results and Discussion

Subjecting the mussels to starvation in sand-free water for a day, followed by immersion in chlorinated water, helped to minimise the sand content in the meat. The mussels were opened with suitable sharp instruments without heating. Heating the mussels in open vats and then shucking the meat may involve some loss of nutrients. Again, when the shucked meat is subjected to blanching, the soluble nutrients are lost. To reduce the loss of nutrients to a possible minimum, the meat was shucked from live mussels.

Blanching the meat for 5 min in 5% brine gave about 3% salt to the product. Dipping the meat in brine of higher concentration for a prolonged period did not enhance the quality. As is evident from Table 1, it led to an increase in the concentration of salt in the meat and a consequent depletion of the total nitrogen content. To avoid this apparent reduction in food value, the concentration of brine was maintained at 5% and the duration of blanching 5 min.

Table 1. *Effect of salt concentration on the quality of smoked mussel*

Concentration of brine %	Blanching time min	Salt content % DWB	Total nitrogen % DWB	Remarks
5	5	2.81	7.652	Characteristic sweet taste and flavour; salt taste normal
10	5	4.25	6.951	Salt taste masks the sweet taste and flavour
15	5	6.14	6.548	Highly saltish
5	10	4.19	6.953	Prominently saltish, masking the sweet taste and flavour of the meat
10	10	6.35	6.604	Highly saltish
15	10	7.05	6.315	Highly saltish

Table 2. *Effect of smoking time on the quality of smoked mussel*

Moisture content before smoking %	Smoking time min	Moisture content after smoking %	Remarks
48.75	15	42.15	Partial smoke absorption; sticky to touch
	30	31.04	Uniform characteristic smoked colour and flavour which blends well with the sweet flavour of the meat
	60	22.54	Dark unattractive appearance; meat is shrunken and tough in texture
	120	15.75	Unattractive; very dark colour; reduced in size; tough texture

Table 3. *Proximate composition of smoked mussel*

Moisture	%	...	10.89
Chloride as NaCl (DWB)	%	...	2.81
Total nitrogen (DWB)	%	...	8.765
Ash (DWB)	%	...	11.32
Acid insolubles DWB	%	...	0.0581
Glycogen (DWB)	%	...	22.15
Fat (DWB)	%	...	11.51

Partial reduction in the moisture of the blanched meat to about 40-45% immediately before smoking was found necessary for better and uniform absorption of smoke. To achieve this, the meat was partially dried in a dryer for 30 min prior to smoking. In the smoke kiln the meat was spread on rust-free wire trays. Smoking at 80-90°C for 30 min gave the product the characteristic smoked colour and flavour. Less than 30 min was found insufficient for complete smoke absorption and prolonged smoking resulted in dark, tough and disfigured product (Table 2).

The smoked product was either sun-dried or dried in dryers to 10% moisture level. At this moisture the product could be stored without spoilage for more than six months. The yield of the final product was found to be 22%. The proximate composition of the smoked mussels is given in Table 3.

The authors are thankful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology for permission to publish the paper and to S/Shri V. Gopalakrishna Pillai and T. John of this Research Centre for technical assistance.

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A Method for the Preparation of Cooked-Peeled-Frozen Prawns

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Several consignments of cooked-peeled-frozen prawns exported from India were rejected last year due to high total plate count (TPC) at 30°C. The specified temperature of incubation for TPC in our country is 37°C. Hence the effect of incubation at 30 and 37°C on TPC was studied. It is seen that the count is higher on incubation at 30°C. A method for production of cooked-peeled-frozen prawns conforming to the specification for TPC at 30°C is standardised and is reported. It consists of re-cooking the cooked-peeled prawns followed by packing and freezing without further contamination. The method minimises batch to batch or sample to sample variation in TPC.

The technology for the production of bacteriologically sound cooked-peeled (CP) frozen prawns was reported by Iyer *et al.* (1969). Since then production and export of this item remained without any problem till last year when several consignments were rejected owing to higher total plate count (TPC). The Export Inspection Agency stipulates a maximum TPC of 1,00,000/g at 37°C. Hence investigations were carried out with a view to establishing the differences in TPC at 30 and 37°C and working out a procedure for the preparation of this item with as low a TPC at 30°C as possible.

Materials and Methods

Commercial samples of cooked peeled frozen prawns which remained in stock at the time of this crisis were examined for TPC at 30 and 37°C by standard procedures (IS: 2237-1971). Commercially produced cooked and peeled prawns were subjected to heat treatment by dipping in 3% boiling sodium chloride solution for one minute before freezing and bacteriological analysis on the production line starting from the raw prawns was carried out. End product obtained as per the proposed flow chart was also examined for bacterial quality. In all cases 5 samples each were examined from the same code/batch. In addition to TPC, samples were simultaneously tested for *E. coli*, faecal streptococci and coagulase

positive *staphylococci* by methods outlined in Indian Standard Specification for Frozen Prawns (shrimp) (IS: 2237-1971).

Results and Discussion

Total plate count at 30 and 37°C of commercial frozen cooked and peeled prawns held in stock at the time of the crisis is shown in Table 1. Table 2 presents changes in TPC at 30°C during different stages in the production of CP frozen prawns. Data on TPC at 30 and 37°C of CP frozen prawns prepared as per the proposed flow sheet is shown in Table 3.

Table 1 clearly indicates that TPC at 30°C is definitely higher than that at 37°C. This is explained as follows: Cooking of raw prawns destroys the natural flora. Whatever bacteria added on further are terrestrial. The prevalent atmospheric temperature is 27-32°C. Hence the bacteria added on after cooking grow better at 30°C and hence higher TPC at 30°C. The data also shows lack of uniformity in TPC from code to code and even from sample to sample for the same code. This is attributable to the variations in sanitary conditions of the processing environment.

Table 2 shows that cooking of raw prawns results in very low TPC which increases during peeling. Re-cooking reduces

Table 1. *Total plate count of commercial frozen, cooked and peeled prawns*

Batch/Code	Total plate count/g ($\times 10^3$)	
	30°C	37°C
A	31.0	1.5
	5.9	1.2
	10.4	3.2
	24.2	0.5
	1.9	5.2
B	0.3	0.1
	0.1	0.1
	0.6	0.3
	1.2	0.6
	1.2	0.1
C	27.0	0.2
	0.5	0.2
	3.5	0.8
	2.5	0.3
	3.0	0.3
D	233.0	0.8
	4.0	0.9
	145.0	3.2
	18.5	2.2
	3.5	0.5
E	5.2	2.6
	67.0	4.3
	19.6	5.3
	223.0	67.1
	13.7	1.4

Note: *E. coli*, faecal streptococci and coagulase positive staphylococci were absent

Table 2. *Changes in total plate count/g of prawns during different stages in production of cooked-peeled-frozen prawns (incubation temperature 30°C)*

Raw prawns, whole, before cooking	: 2,20,000
Whole prawns, immediately after cooking	: < 100
Whole cooked prawns immediately after cooling	: 200
Cooked prawns after peeling	: 2,400
Cooked, peeled prawns after sorting and grading	: 1,20,000
Cooked, peeled prawns after washing	: 1,00,000

(Contd.)

Table 2. (Contd.)

Cooked peeled prawns after re-cooking	: 250
Recooked prawn meat after cooling	: 1,000
Recooked prawns after filling in freezing trays and addition of glaze water	: 1,200
-do- after freezing	: 1,300

Note: *E. Coli*, faecal streptococci and coagulase positive staphylococci were absent

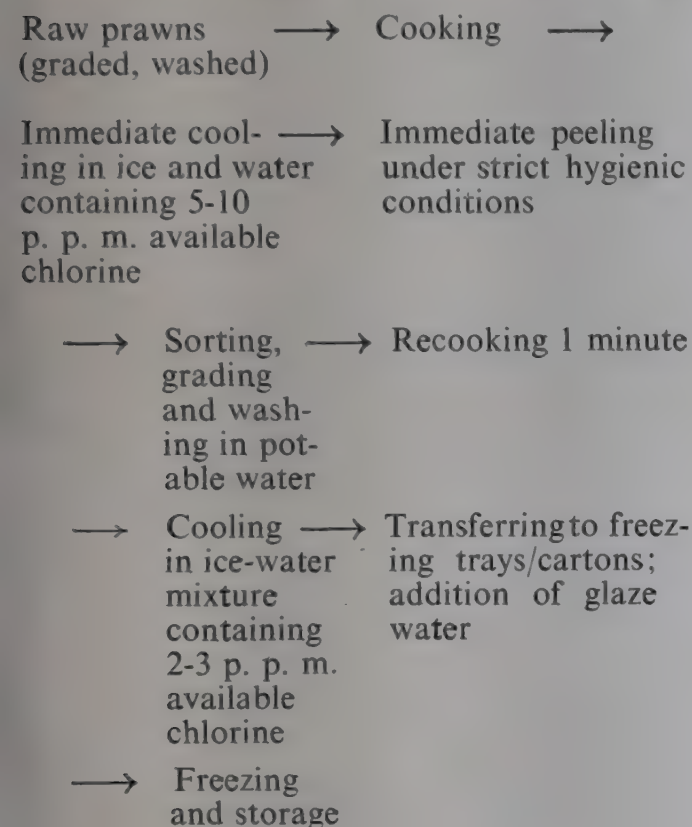
Table 3. *Total plate count of cooked-peeled-frozen prawns produced as per the proposed method*

Batch/Code	Total plate count/g ($\times 10^3$)	
	30°C	37°C
A	1.8	0.1
	6.8	0.6
	6.9	0.6
	17.9	1.0
	1.5	0.7
B	3.2	1.3
	2.4	0.3
	3.7	1.1
	1.2	0.05
	1.6	0.08
C	0.8	0.4
	2.4	0.3
	1.2	0.7
	1.3	0.6
	0.8	0.2
D	1.4	0.7
	1.8	3.8
	2.7	3.9
	0.5	3.2
	0.7	4.4
E	2.0	0.7
	3.9	0.1
	8.6	1.9
	4.9	0.2
	1.0	0.9

Note: *E. coli*, faecal streptococci and coagulase positive staphylococci were absent

the count and remains constant afterwards. It is clear from Table 3 that TPC in the end product is well below the limit and there is very little variation in its level from code to code or from sample to sample.

Flow sheet for production of CP frozen prawns



Recooking is done in boiling 3% sodium chloride brine. Before cooking, the material shall be filled in perforated individual trays which can hold the required weight of shrimp for one slab. The dimensions of the tray shall be such that it can just fit in the freezing tray or duplex carton when inverted. When a freezer load of cooked-peeled prawns is ready, they shall be filled into the perforated trays, covered with perforated lid, recooked, cooled and the material transferred for freezing without contact with other surface.

Other variations of the method like recooking the cooked peeled prawns as a lot and then packing or recooking at a lower temperature, say about 85°C are also possible but are less safe. The yield from whole prawns in this method is 30-33% compared to 33-36% without recooking.

The authors are grateful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology, Cochin for permission to publish the paper.

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Nutritive Value of the Crab *Podophthalmus vigil* (Fabricius)

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Among the edible crabs, *Podophthalmus vigil* occupies a distinct position in Porto Novo coast. Though the fishery is seasonal, *P. vigil* supports an additional crab fishery from August to October. An attempt has been made to evaluate the nutritional status of different size groups of *P. vigil*. It has been observed that protein and moisture values are more in smaller crabs, corresponding with a drop in carbohydrate and fat. In bigger size groups, the values of fat and carbohydrate are found to be higher, while protein and moisture contents decreased slightly. The total meat content varies in different crabs of the same size group and the average value of the total consumable part is found to be only less than 30% of the total weight of the animal.

De Man (1887) first described the genus *Podophthalmus*. *Podophthalmus vigil* was first collected by De de Daldorff from the east coast of India. Srinivasagam & Natarajan (1976) described the early development of *P. vigil* in the laboratory with a note on the importance of its fishery in Porto Novo. This species exhibits sexual dimorphism; the males are with larger bluish violet chelae. Since they are highly preferred as food, an attempt has been made to estimate the protein, carbohydrate, fat and water contents in relation to size.

Materials and Methods

Fresh crabs of various size ranges were collected and grouped into five, based on the carapace width. Protein was estimated by the Biuret method (Raymont *et al.*, 1964), carbohydrate by Dubois method (Dubois *et al.*, 1956), fat according to Folch & Stanley (1956) and moisture content by gravimetric method. For the determination of total meat content, the crabs were boiled, meat separated and weighed. Ovigerous females, moulting crabs and crabs with regenerating limbs were not included.

Results and Discussion

Protein, carbohydrate, fat, water and total meat contents are given in Tables 1 and 2. Crabs with carapace width 51-60 mm recorded higher protein values while fat and carbohydrate were found to be lower. In

61-70 and 71-80 mm groups there was an initial fall and subsequent rise in protein values, while carbohydrate and fat were on the increase. The moisture was maximum in the 51-60 mm group, but lesser in 61-70 and 71-80 mm groups. In the 81-90 mm group protein value declined along with that of carbohydrate and fat while moisture content increased. In 91-100 mm group the protein and moisture contents were found to be minimum while carbohydrate and fat registered the highest.

Regarding the higher protein content during young stage, similar observation has been made by Selvaraj (1977) in the Indian shad *Euplatygaster indica*. This observation is also in agreement with that of Ferguson & Raymont (1974) who reported an increase in the lipid content and fall in protein content in *Euphasia superba* with an increase in body weight.

Maximum moisture content was found in 51-60, 61-70 and 81-90 mm group with lower lipid contents. Minimum moisture contents were observed in the crabs of the 71-80 and 91-100 mm group. The presence of more carbohydrate and fat in full grown crabs (91-100 mm) may be due to the storage of these materials in tissues and the low frequency of moulting. During the period of active growth possibilities of large scale storage of fat and glycogen are less. No relationship between body size and the total meat content was observed in the present

Table 1. Protein, carbohydrate, fat and water contents in different size groups of *P. Vigil*

Carapace width mm	Protein %	S. E.	Carbohydrate %	S. E.	Fat %	S. E.	Water %	S. E.
51-60	19.58	± 1.78	0.30	± 0.05	4.30	± 1.54	74.46	± 2.28
61-70	18.04	± 2. 3	0.52	± 0.03	5.13	± 2.63	72.14	± 1.48
71-80	20.16	± 1.45	0.63	± 0.07	6.88	± 2.55	70.23	± 1.82
81-90	18.95	± 2. 6	0.45	± 0.05	5.72	± 1.79	72.30	± 2.73
91-100	15.75	± 1: 8	0.58	± 0.04	9.73	± 1.66	69.54	± 2.86

Table 2. Total meat content in various size groups of *P. Vigil*

Carapace width mm	Total animal weight g	Meat content %
95.00	73.00	23.08
96.20	73.40	17.85
104.00	71.00	28.24
96.50	75.00	14.33
95.00	58.73	12.77
84.24	45.60	9.43
66.42	28.71	14.61
96.30	60.10	13.97
86.00	45.61	8.77
83.00	56.60	10.93
80.01	48.47	12.34
74.20	36.22	9.58

study. The reason for this variation is not known. Chinnamma George & James (1971) observed a linear relationship between

the meat weight and the body length in the crab *Scylla serrata* during full moon and new moon periods. Increase in meat content was observed at new moon time compared to the full moon. However no such variations could be observed in the present study on *P. vigil*. It has been observed that the actual consumable part in the *P. vigil* to be less than 30% of the total weight.

The authors are grateful to the University Grants Commission for financial assistance.

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Seasonal Changes in the Biochemical Composition of Liver in *Garra mullya* (Sykes)

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Seasonal changes taking place in the biochemical constituents of liver of *G. mullya* are reported. An inverse relationship was noticed in the variation of fat and water. Maximum fat contents were observed during June-July. Reserve fat was utilised through gluconeogenesis during the spawning months. Protein and glycogen percentages were comparatively higher in liver than in the muscles and gonads. Decline in the glycogen content was associated with spawning during July to November. Nutritive values have shown more energy contents in the liver during pre-spawning months.

Liver being one of the main organs of the body controlling the metabolism of the fish, studies on its chemical composition and food value are of paramount importance. Studies on chemical composition of liver of fresh water as well as marine fishes of India have been carried out by various workers (Jafri & Qasim, 1965; Jafri & Khawaja, 1968; Savant & Bal, 1969). However the information on seasonal changes in various biochemical constituents of the liver in hill stream fishes is scanty. Hence an attempt has been made to investigate quantitative changes in water, fat, protein and glycogen content of the liver in hill stream fish, *Garra mullya* (Sykes) during different months.

Materials and Methods

Freshly caught fishes from Kham river near Aurangabad were brought to the laboratory every fortnight and liver samples were collected sexwise. After removing the water from the surface of liver samples with blotting paper, the weights were recorded to the nearest milligram. The samples were then dried in an oven at 100°C till constant weights were obtained. The experimental methods employed for the estimation of water, fat, protein and glycogen were that followed by Somvanshi (1978)

Results and Discussion

The seasonal changes in the biochemical composition of liver of male and female fish (Figs. 1 to 4) were significant and had some correlation with various activities of the fish like feeding and spawning.

Variations in the fat and water percentages in the liver of males and females are shown in Fig. 1. Percentage of water varied from 69.32 (in June) to 74.67 (in January) in males and 69.23 (in July) to 75.35 (in January) in females, whereas the percentage of fat fluctuated between 2.83 (in March) and 5.54 (in June) in males and 2.28 (in March) and 4.97 (in July) in females.

In general, the changes in the liver fat and water are similar to that observed by Somvanshi (1978). The percentage of water in liver of both the sexes was comparatively high during the spawning season, namely, June to November (Somvanshi, 1976). This indicated that the percentage of water was more in the spent, immature and the maturing specimens. Jafri & Khawaja (1968) and Mehta (1974) have also observed similar trends in the variation of water content in liver of *Ophiocephalus punctatus* and *O. gachua* respectively.

The values for fat were high during the pre-spawning and spawning months, thus showing that the mature specimens which

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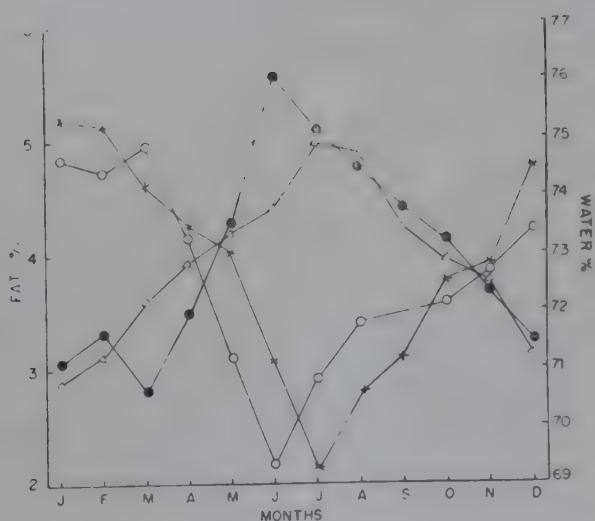


Fig. 1. Percentage variation of fat and water in the liver of males and females

○—○ Water (in males); ●—● Fat (in males);
×—× Water (in females); △—△ Fat (in females)

are ready for spawning have maximum accumulation of liver fat. A fall in the fat value was observed towards the end of the spawning season, indicating that a major part of the accumulated fat is used up owing to spawning. It is known that the sexual maturation in fishes is related to the muscle and liver glycogen (Greene, 1926 and Black *et al.*, 1961). Fish during its breeding migration and spawning act requires more of glycogen and the depletion of liver fat may be due to the conversion of fat into carbohydrate through metabolic pathways (gluconeogenesis) which leads to the maintenance of an adequate glycogen level re-

quired both by the increased muscular activity and the spawning exertion. It is also noticed that during spawning, feeding is less in *G. mullya* (Somvanshi & Bapat, 1978) and the increased demand for glycogen is met by the conversion of stored liver fat into glycogen.

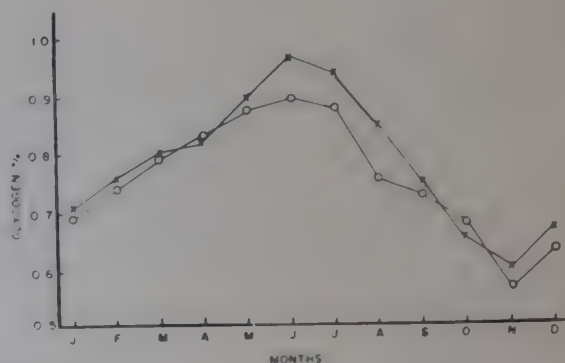


Fig. 3. Percentage variation of glycogen in males and females

○—○ Males; ×—× Females

A rise in liver fat was noticed from February onwards which indicates restorage in the liver fat consequent on increased feeding activity. Jafri & Khawaja (1968) have noted highest value for liver fat during the peak ripening period of eggs and thereby decreasing with the onset of spawning. It may also be added that for meeting the energy demand of gonads during development, the utilization of muscle fat alone is insufficient. The liver fat also is used up. It can be inferred that the liver in *G. mullya* acts as a store house of energy reserves, the fat and water have inverse relationships.

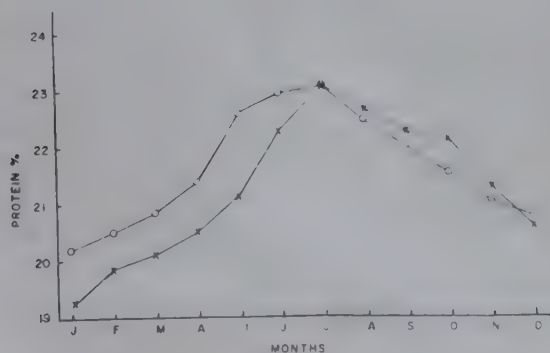


Fig. 2. Percentage variation of protein in males and females

○—○ Males; ×—× Females

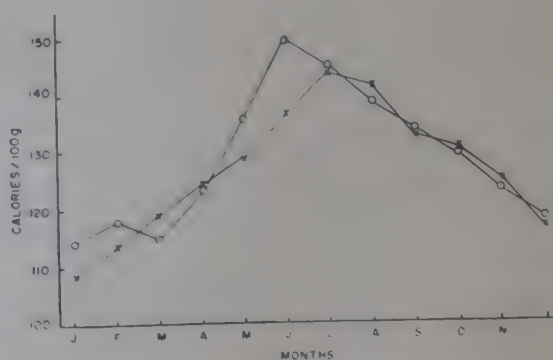


Fig. 4. Seasonal variation of energy values in males and females

○—○ Males; ×—× Females

The variation of protein in the liver of *G. mullya* is shown in Fig. 2, for males and females separately. The protein values for males varied from 20.19% (in January) to 23.08% (in July) and in females from 19.25% (in January) to 23.08% (in July). In general, the values for liver protein are comparatively higher than that in muscles and gonads of both the sexes (Somvanshi, 1976). Fig. 2 shows that there is a steady increase in the liver protein from May onwards reaching its peak in July in both the sexes, subsequently decreasing during spawning season. Low liver protein values were recorded during the post-spawning months. The accumulation of protein in liver during the process of ripening of eggs indicates that the liver as the major source of nitrogen for the fish for spawning.

The changes in liver glycogen values in different months are presented in the Fig. 3. The percentage of glycogen in liver varied from 0.56 to 0.99 and 0.59 to 0.96 in males and females respectively. The highest values were recorded in June and the lowest in November. The liver glycogen increased gradually from December onwards, reaching the maximum in June which coincides with the attainment of maturity. It declined thereafter consequent on spawning and reached its lowest value in November towards the end of the spawning season. Thus it is clear that the glycogen accumulated during the pre-spawning months in liver is used up for spawning from July to November.

Besides water, fat and protein are the major constituents of liver of *G. mullya*. Hence the calorific values are chiefly due to protein and fat whereas glycogen accounts very less in energy value. However, maximum glycogen was noticed in liver when compared to the other tissues of the fish

(Somvanshi, 1976). The sexwise seasonal variations in energy values are presented in Fig. 4. The liver calorific values varied from 114.35 (in January) to 149.63 (in June) in males and 108.71 (in January) to 144.49 (in July) in females. The energy values for protein, fat and glycogen were high during the pre-spawning months and decreases while spawning (June-November).

The author records his sincere thanks to Dr. (Mrs.) S. S. Bapat, Reader in Zoology, Marathwada University, Aurangabad, for guidance and to Dr. R. Nagabhushanam, Professor and Head, Department of Zoology, Marathwada University, Aurangabad, for providing laboratory facilities.

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Filleting of Fish and Utilization of Filleting Waste

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A manual method of filleting of different varieties of fishes, yields of skin-on and skinless fillets that can be obtained from them, levels of recovery of picked meat from the filleting waste and the utilization of the latter for the production of fish meal have been reported in this communication. The compositions of meal thus prepared are also given.

Indian fish landings consist of several species of fishes like cat fish (*Tachysurus* sp.), Indian halibut (*Psettodes erumei*), jew fish (*Pseudosciaena* sp.) etc. which can be processed into fillets with good consumer acceptability. At present filleting of fish is done only on a limited scale in our country, though fish fillets fetch good price in markets within the country and abroad. Very little research work has been carried out on the filleting of fish in our country. Menon & Samuel (1975) studied the production and economic aspects of marketing picked meat (minced meat) from trash fish and fillets from a few varieties of fishes. The freezing and storage characteristics of fresh and iced skin-on fillets of seer have been studied by Shenoy (1976). Devadasan *et al.* (1978) studied the frozen storage characteristics of fillets from six species of fresh water fishes. However, filleting of fish has not been adopted by the trade, the main reason being the non-availability of technological know-how regarding the process, information regarding the yield of fillets and the utilization of sizable quantities of the waste that is left behind. Mechanical devices for filleting and skinning are not available in our country and the imported machineries are very expensive. Further, sufficient raw material will have to be made available to feed and operate these machines economically.

This paper reports the studies made at CIFT on hand filleting and skinning of different varieties of fishes, yields of fillets obtainable from them, the possibility of recovery of picked meat from the filleting waste and utilizing the waste for the production of fish meal.

Materials and Methods

The fishes used for the study included cat fish (*Tachysurus* sp.), Indian halibut (*Psettodes erumei*), perch (*Lutianus malabaricus*), kalawa (*Plectoropomus* sp.), milk fish (*Chanos chanos*), ribbon fish (*Trichiurus* sp.), seer fish (*Scomberomorus guttatus*) and jew fish (*Pseudosciaena* sp.). These were obtained in fresh condition from the landing places at Fort Cochin or from the Integrated Fisheries Project's vessels. The fishes were brought to the laboratory immediately after landing, washed in potable water, stored in crushed ice and used for filleting.

Hand filleting was adopted and an outline of the general method of filleting is given below.

1. Graded the fish according to size and weighed.
2. Removed scales if any and viscera and washed in potable water.
3. Placed the fish on its side on the filleting table and driven in a sharp knife vertically from just behind the base of the pectoral fin until it touched the main bone at the back of the head. Tilted the knife towards tail and slid it along the line of the dorsal fin and removed the fillet.
4. Turned the fish over and separated the fillet from the other side exactly as described above.
5. Trimmed the fillets to remove belly flaps, fins etc. and weighed.

Table 1. *Yield of fillets, picked meat and waste meal from different varieties of fish*

Name of fish	Size grade g/fish	Yield on the basis of whole fish			
		Skin-on fillets %	Skinless fillets %	Picked meat %	Waste meal %
Cat fish	400-750	31.1-33.4	25.0-28.0	8.9-9.7	13.5-17.1
Indian halibut	450-1096	48.6-51.2	37.1-39.7	7.2-8.4	10.3-11.7
Perch	2060-2530	38.7-39.5	30.2-31.6	5.9-6.3	10.4-12.2
Kalawa	1250-2650	38.4-39.9	31.2-32.0	5.7-7.1	18.0-19.7
Milk fish	756-819	49.1-50.6	39.5-40.6	6.8-8.4	15.4-17.0
Ribbon fish	450-630	36.0-37.8	29.1-30.4	8.2-9.4	10.8-12.6
Seer fish	3500-4255	51.2-52.7	45.0-47.5	6.7-7.5	10.6
Jew fish	142-156	41.1-42.2	33.6-34.8	6.3-6.6	10.92-11.8

Table 2. *Composition of filleting waste meal*

Name of fish	Moisture %	Total ash %	Acid insoluble ash %	Fat %	Crude protein % (TN x 6.25)
Cat fish	6.67	29.27	0.08	20.62	43.94
Indian halibut	5.39	22.62	0.09	15.54	56.24
Perch	4.91	32.63	0.10	6.54	53.90
Kalawa	6.40	33.82	0.14	4.34	53.07
Milk fish	5.29	18.56	0.13	29.55	45.47
Ribbon fish	7.22	32.83	0.04	7.94	51.13
Seer fish	3.36	17.97	0.06	27.06	50.37
Jew fish	5.50	28.39	0.06	9.62	54.44

To remove the skin cut nick in tail of the fillet using a thin bladed knife longer than the width of the fillets. Angled the knife slightly downwards and pulled skin across the knife while at the same time making slight saw cutting movement with the knife.

Washed the skinned fillets thoroughly in water, allowed to drain for 5 minutes and weighed. Calculated the percentage yields of skin-on and skinless fillets.

The filleting waste contained considerable quantity of meat which could be recovered by suitable method. The meat adhering to bones and that present in the head portions were separated by a hand operated meat bone separator and the quantity of meat recovered in respect of different types of fishes noted.

The filleting waste after recovery of meat was cooked in an autoclave at 112°C

for 30 min, the cook drip drained off and residue dried as such either in the sun or in the tunnel drier (temp. 50–55°C). Fat was not removed by pressing. The dried material was powdered and used for further analysis. Moisture, fat, total ash, acid insoluble ash and crude protein were determined by the methods of AOAC (1960).

Results and Discussion

Table 1 gives the yields of skin-on and skinless fillets (without belly flaps), picked meat from the filleting waste and meal obtained by cooking, drying and pulverising the waste in respect of different species of fish studied. Maximum yield of skin-on and skinless fillets were obtained from seer (51.2–52.7 and 45–47.5% respectively) and the minimum from cat fish (31.1–33.4 and 25–28% respectively). Manual filleting worked well with all the varieties of fishes studied and the yields obtained were good. Appearance of the fillets was quite attractive in the case of both skin-on and skinless fillets. A skilled worker could fillet and skin 10–12 kg of fishes like cat fish, perch or milk fish per hour.

During the filleting process, the belly flaps are separated from the whole fillet as they are liable to discolour on subsequent storage. Their removal imparts an attractive appearance to the fillets. The belly flaps can be sold on the subsistence market, while the fillets would command a much higher price in the luxury market.

The maximum quantity of picked meat recovered from the filleting waste ranged from 8.4 to 9.7% in the case of cat fish, milk fish, ribbon fish and Indian halibut showing that considerable quantity of meat is left

behind on the bones and in the head portions, while in others it varied from 5.7 to 7.5% on the basis of whole fish. The yield of waste meal obtained by cooking, drying, and pulverising the filleting waste (after recovery of picked meat) was 18 to 19.7% from kalawa and the other fishes showed wide variations from 10.3 to 17.1%.

The compositions of the meal are given in Table 2. It can be seen that the crude protein content of the meal prepared from the filleting waste of many of the fishes studied was above 50%, which is the protein content of grade 2 fish meal (IS:4307–1967). But in the case of cat fish and milk fish the protein contents of the meal were 43.94 and 45.47% respectively. The acid insoluble ash of the meal was quite low in all the samples. The fat content of the meal was high in some of the samples (cat fish, seer fish and milk fish). This is due to the fact that the meal was prepared without pressing the cooked filleting waste.

The authors are thankful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology, Cochin for permission to publish the paper.

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Studies on Smoke Curing and Preservation of Oil Sardine (*Sardinella longiceps*)

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A method is reported for smoke curing of oil sardine (*Sardinella longiceps*) by dry salting in the ratio of 1:6 (salt to fish), followed by smoking in the traditional smoke chamber in two stages, (1) at 45°C for 3 h and (2) at 75°C for 2 h with smoke generated from coconut husk, wood shavings and saw dust in 2:2:1 proportion. The product obtained had good odour, flavour, golden yellow colour and a shelf-life of 8 weeks at room temperature (26 to 28°C)

Oil sardine constitutes about 30 per cent of total marine fish landings of our country and the most abundant and commercially important species on the west coast. Due to lack of preservation facilities, a considerable quantity of it is converted into fertiliser. One method of avoiding such wastage of high quality fish is to preserve them by smoke curing, which is very simple and popular in the Far East and continental countries, where a variety of cold and hot smoked products are prepared and marketed. Unlike in India, extensive studies have been carried out on various aspects of this method of curing in those countries. Although some work (Anon, 1966, 1968; Solanki *et al.*, 1970; Kandoran *et al.*, 1971) has been reported on the preservation of lean and medium fatty fishes by hot smoking process, a satisfactory method for smoke curing of fatty fish like oil sardine, suited to the Indian conditions has not been developed. Moorjani & Vasantha (1972) have reported a method for hot smoking oil sardines, but the shelf-life of the product was only 2 to 3 days at room temperature. Muraleedharan *et al.* (1976) have recommended the use of sodium propionate to enhance the shelf-life and butyl hydroxyanisole (BHA) to control the rancidity in smoked products. The present paper reports a method to prepare acceptable smoked oil sardine without chemicals.

Materials and Methods

Fresh oil sardines of length 13–14 cm were obtained from the landing centre at

Mangalore. A traditional vertical smoke chamber fabricated was used for the experiment. The chamber made of mild steel sheet was provided with an asbestos lining inside and facilities for generating smoke, reading temperature, metallic rods for hanging the fish and gas exhaust. Relative humidity was read from a wet bulb thermometer fixed inside the chamber. Saw dust, wood shavings and coconut husk in the ratio 1:2:2 were spread as bed, 30 cm deep, and burnt without flame to generate the smoke. Additional quantity of wood was used during smoking process to maintain the desired temperature of smoke. The fish were washed to remove any adhering dirt, gutted, cleaned, split ventrally and black peritoneal membrane removed. They were then salted in the ratio 1:6 (salt to fish) and stacked in salting tanks overnight. Top-most layer of fish was covered by a layer of salt to avoid exposure to air. Cured fish was then rinsed in fresh water to remove excess salt, hung on clean metallic rods and drained for 15 min. The fish were then loaded into the smoke chamber and smoked in two stages, (1) at 45 °C for 3h and (2) at 75 °C for 2 h, keeping the relative humidity inside the chamber at 60 to 70%. The fish attained a characteristic golden yellow colour and flavour and moisture content fell below 40%. The product was cooled, sealed in coloured polythene bags and stored at room temperature for assessing the shelf life. The yield was 18 to 20%. Salted and sundried oil sardines also were stored

Table 1. *Effect of smoking on dry salted oil sardine at 45°C for 5 hours*
(Period of salting: 12 h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Storage period (days)	Overall acceptability (odour, flavour and colour)	Symptoms of spoilage
1	1:2	49.41	9.10	15	Uncooked taste internally and smoky externally. Not acceptable	Mould growth and rancid flavour
2	1:3	47.12	9.80	18	-do-	-do- With change of colour from golden yellow to dark brown and oozing of oil
3	1:4	48.27	10.30	16	-do-	-do-
4	1:5	46.10	11.08	17	-do-	-do-
5	1:6	45.50	11.19	19	-do-	-do-

Table 2. *Effect of smoking on dry salted oil sardine at 75°C for 5 hours*
(Period of salting: 12h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Remarks
1	1:2	34.10	17.81	Oozing of fat and poor acceptability due to development of dark colour, salty taste, tough texture, precipitation of salt.
2	1:3	33.00	16.92	
3	1:4	34.85	17.52	
4	1:5	34.92	17.82	
5	1:6	33.08	18.72	

Table 3. *Effect of smoking on dry salted oil sardine at 45°C for 3 hours and 75°C for 2 hours*
(Period of salting: 12 h)

Sample	Ratio of salt to fish	Moisture %	Sodium chloride % (OWB)	Storage period (days)	Overall acceptability (odour, flavour, colour)
1	1:2	37.30	12.22	25	Acceptable
2	1:3	37.11	15.30	49	-do-
3	1:4	36.89	16.17	60	-do-
4	1:5	36.12	16.89	60	-do-
5	1:6	36.78	15.07	61	-do-

Table 4. Analyses before and after salting of oil sardine (1:6)

Stage at which analysed	pH	Moisture %	Nacl % (OWB)	Peroxide value (milli-moles of O ₂ /kg of fat)	FFA %	TMAN mg/100g	TVN mg/100g	Plate count/g
Before salt curing	6.2	66.00	0.64	Negligible	0.01	—	6.0	25 x 10 ⁵
After salt curing	6.1	58.00	5.49	2.12	0.62	1.42	16.60	12 x 10 ³

under the same conditions as reference samples.

Estimations of moisture and sodium chloride were carried out according to AOAC (1950) methods. Oxidative rancidity was determined by organoleptic evaluation and peroxide values (Tarr, 1947). Free fatty acids (FFA) were estimated by the method of Dyer & Morton (1956). Total volatile nitrogen (TVN) and trimethylamine (TMA) were estimated on a trichloroacetic acid extract (Beatty & Gibbons, 1936) and phenolic content of smoked product by the method of Foster & Simpson (1961). Total viable count was determined by using nutrient agar medium and incubating at ambient temperature for 48 h. The presence of *E. coli*, faecal streptococci, coagulase positive styphylococci, salmonella and aerobic spore-formers was tested using standard media as recommended by APHA (1966). Subjective evaluation of the product (meat portion separated from skin and bone) was carried out by a taste panel of ten members using a Hadonic scale: A=like very much (10 marks); B=like much (8 marks); C=like (6 marks) ; D = neither like nor dislike (4 marks) and E=do not like (2 marks). Instead of trying the acceptability on individual attributes, overall acceptability of the product was judged statistically following the method of analysis of variance of Krammer & Twigg (1970), as modified by Udupa & Jayaram (in press). The rate of dehydration was determined by drawing samples during smoking process at intervals of one hour and estimating the moisture content.

Results and Discussion

The proximate composition of oil sardine used for the experiment was protein,

Table 5. Rate of fall in moisture contents in relation to relative humidity and temperature of smoking

Smoking time h	Temperature °C	Relative humidity %	Moisture content %
1	45	60	53.8
2	45	65	50.2
3	45	65 to 70	46.0
4	75	70	40.0
5	75	65 to 70	37.4

Initial moisture : 58.0%

16.38%; fat, 16.20%; moisture, 66.00% and ash, 1.42%. The results of preliminary experiments to determine the optimum conditions of smoking are presented in Tables 1, 2 and 3. It may be seen from Table 1 that dry salting in ratios of 1:2 to 1:6 and smoking at 45°C for 5 h could preserve the product for 15 to 19 days only before spoilage, mainly due to mould growth. Reduction in moisture content was comparatively less and there was no oozing of fat in this process. The products were not acceptable because of uncooked (raw fish) taste.

Samples salted in the same ratios and smoked at 75°C for 5 h showed very high salt content, tough texture, reduced moisture contents and dark discolouration (Table 2). Oozing of fat during smoking was very high. The products were not acceptable and hence not preserved to study their storage quality. But the samples smoked at 45°C for 3 h and subsequently at 75°C for 2 h (total 5 h)

Table 6. Storage characteristics of smoked oil sardine

Characteristics	Immediately after preparation	One week	Two weeks	Three weeks	Four weeks	Five weeks	Six weeks	Seven weeks	Eight weeks
	1	2	1	2	2	2	2	2	2
pH	5.80	5.90	5.80	6.00	6.00	5.80	5.70	5.70	5.80
Moisture %	37.12	36.91	36.56	35.24	35.44	35.74	36.40	36.83	35.82
NaCl % (OWB)	15.90	16.12	15.02	14.80	14.67	13.96	14.12	13.82	13.69
Peroxide value (millimoles O ₂ /kg fat)	40.12	91.01	120.00	26.66	32.09	25.60	21.44	20.19	21.09
FFA % (as oleic acid)	5.72	8.11	16.00	8.14	14.40	16.00	5.60	14.12	12.00
TMAN mg/100g	5.17	—	—	2.66	5.12	8.12	5.10	11.14	10.12
TVN mg/100g	20.08	37.08	—	21.28	21.18	26.32	40.04	56.12	60.12
Organoleptic evaluation	A	ASR	UHRR	A	A	A	A	A	LA
Plate count/g	< 300	—	—	40x10 ³	38x10 ³	42x10 ³	21x10 ³	—	30x10 ³

1—Control (salted and sundried)

2—Salted and smoked

A : Acceptable

ASR : Acceptable, slightly rancid

UHRR : Unacceptable, highly rancid and rusty

LA : Less acceptable due to loss of flavour and colour

showed promising results (Table 3). The products remained in acceptable condition for 25 to 61 days with golden yellow colour, flavour and odour. Hence salting in the ratio of 1:6 and smoking for 3 h at 45 °C and 2 h at 75 °C were fixed as the optimum conditions which were adhered to in further experiments. The results of chemical analysis and counts for aerobic microorganisms before and after salt curing of oil sardines in 1:6 ratio are presented in Table 4. The rate of fall in moisture content in relation to relative humidity and temperature of smoking for 5 h (at 45 °C for 3 h and 75 °C for 2 h) is presented in Table 5. The changes occurring in the smoked products during storage at room temperature are presented in Table 6.

It may be seen from Table 6 that controls deteriorated quickly with development of both free fatty acids (FFA) and peroxides, dark brown discolouration and rancid flavour within two weeks and became unacceptable, while the experimental samples remained well at room temperature for 8 weeks before losing original flavour, colour and acceptable texture. The samples showed salt encrustation, but no mould growth. TMAN increased gradually in storage. Moisture and sodium chloride contents were about 37 and 16% respectively. The phenolic content was 11.2 mg/100 g of steam volatile and 4.5 mg/100 g of steam non-volatile phenols.

The samples did not show presence of *E. coli*, faecal streptococci and coagulase positive staphylococci and salmonella either during processing or storage. However, aerobic spore-formers were encountered. There was no growth of mould during the period of 8 weeks of storage. The total counts were of the order of 10¹ to 10⁴ which were appreciably low.

Statistical analysis showed that there is significant difference between the 4 attributes (colour, texture, taste and flavour) on their acceptability. When least significant difference based on 't' test (l_sd_{t0.05}) is calculated to isolate the differences among attributes, it was found that there was no difference between colour and texture, and also between flavour and taste. In other words, product is most acceptable with regard to colour or texture, but not so with

Table 7. Analysis of variance

Source of variation	df	ss	ms	F
Between attributes	3	53.225	17.741	37.037*
Error	36	17.250	0.479	
Total	39	70.475		

* Significant at 5% level
(l_sd)_{t 0.05}=0.6284

regard to flavour or taste. The mean scores per panelist are 7.80, 7.55, 5.40 and 5.35 respectively for colour, texture, flavour and taste. Further, Table 7 shows that the effect of extraneous factors on the acceptability of smoked fish are of lesser importance.

Smoked products are stable only if they are sufficiently dehydrated or if the salt content is sufficient to lower the water activity to a level which would not support microbial activity (Chan *et al.*, 1975). Probably the reason for the slow rate of development of PV and FFA is the anti-oxidant property of wood smoke (Banks, 1952), particularly its phenolic content, which must have also contributed to the good taste, flavour and colour.

The low bacterial loads of the samples observed may be attributed to the bactericidal properties of smoke (Hess, 1929; Gibbons *et al.*, 1954). The early spoilage of control samples by rancidity can be due to the high salt content, which have accelerated the oxidation of fat during storage. According to Castell (1965), high salt content causes rancidity with unpleasant odour. But the catalytic effect of almost the same amount of salt is not prominent in the smoked fish product due to the inhibitory action of the smoke. Use of wood smoke with its antioxidant properties is more ideal than synthetic chemicals for controlling rancidity.

The authors wish to express their sincere thanks to Dr. K. Krishnamurthy, Director of Research, University of Agricultural Sciences, Bangalore, Dr. N. L. Lahiry, Professor of Fish Processing Technology and Prof. H. P. C. Shetty, Director of Instruction, College of Fisheries, Mangalore and Shri M. R. Nair, Project Co-ordinator of AICRP, Central Institute of Fisheries Technology, Cochin for their keen interest in the work and to ICAR for financial help.

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Sir,

The last issue of your esteemed journal *Fish. Technol.* 15(2) p. 101 carries a paper entitled "Studies on Equilibrium Moisture Content of Canned Prawn with Particular Reference to Drained Weight" by D. R. Chaudhuri, S. K. Bhattacharyya and H. Ganguli. This paper quotes a portion of the data from my earlier work, namely "Investigations on Canning of Prawns in Brine: Effects of Processing Parameters on Canning Characteristics, Quality and Drained Weight of the Canned Products" presented at the Symposium on Fish Processing Industry in India organised by the Association of Food Scientists and Technologists (India), Mysore, in 1975 and published on pp. 46-52 of the proceedings thereof. This quotation has been summarily out of context, picking out just 6 out of the 25 observations I had reported so as to give a partial and distorted picture of my work.

I have therefore calculated the material balance from the 25 observations spread out in Tables 5 to 9 of my work and the errors derived exactly as reported by Chaudhuri *et al.* These were found to lie on both positive and negative sides. The ranges of the magnitudes of the errors (disregarding the signs) actually occurring and those reported by these authors (all on the positive side) as occurring in my work are presented in the following table.

Range of error %	Occurrence (% of total observations)	
	From the present calculation	As reported by Chaudhuri <i>et al.</i>
0 - 1	32	0
1 - 2	16	0
2 - 3	24	33.3
3 - 4	12	16.7
5 - 6	8	33.3
6 - 7	8	16.7

As described in my original work, the raw materials used by me were from diverse sources, of different species and of varying size grades. The experiments were con-

ducted after varying treatments like storage of raw material in ice for different durations, using different concentrations of blanching brine, different sources (intensities) of heat for blanching and varying blanching times. The studies were on bench scale using refined salt and tap water for blanching and filling brines, graduated glass cylinders for delivering the filling brines and measuring the cut-out brines and rough pan balance (correct to the gramme only) for weighing the filled and cut-out meats. Under these conditions the percentages of errors as seen in the table are quite reasonable and within limits of experimental error. On the contrary, Chaudhuri *et al.* have carried out the experiments on 'conical flask' scale and even if it is taken for granted that analar sodium chloride and distilled water have been used for blanching and filling brines, pipettes/burettes for delivering the filling brine, measuring the cut-out brine and analytical balance for determining the filled and cut-out weights, employing the best analytical skill, the degrees of concurrences of material balance reported in their work appear to be rather far-fetched. This is particularly so, since a material like prawn meat exhibiting highly varying biochemical compositions is involved.

In the beginning of their paper, the authors conclude that the equilibrium moisture content of *canned* prawn is a fixed value, that is, 72.4% by plotting fluctuations in *drained* (cut-out) weights against moisture contents of *blanched* meats. The rest of the work is an attempt to prove this not-so-scientifically derived postulation without making any attempt whatsoever to test its correctness by determining the actual moisture contents of the cut-out meats experimentally. Calculation of the material balance has been done based on this theoretically derived value. The last paragraph of the paper also contradicts the above postulation and says that the equilibrium moisture content should be in the range 72.0 to 74.4%. This is in fair agreement with my work except in two isolated cases of drastic blanching conditions.

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ANNOUNCEMENT

The 60th birthday of Professor Dr. C. V. Kurian, Department of Marine Sciences, University of Cochin falls in November 1979. Professor C. V. Kurian has been associated with the Department of Marine Sciences, Cochin for the past three decades and is one among the few distinguished persons responsible for the development of marine science education in the country. Apart from his on contribution in the field of marine biology, he has the distinction of organising a full fledged department which trains students in all the disciplines of marine sciences.

A number of his students and others associated with him for various periods wish to commemorate the 60th birthday of Dr. Kurian in a befitting manner. An ad-hoc meeting was held and a committee was formed to bring about a commemorative

volume to mark his 60th birthday. It was also decided to institute a suitable fellowship in the Department of Marine Sciences, University of Cochin, in honour of the long and meritorious services of Professor Dr. Kurian. There was heartening response from the former students of Professor Kurian.

Your co-operation and wholehearted association with this endeavour is solicited.

Remittances may kindly be sent to:

Professor Dr. G. S. Sharma
Convener
Professor Kurian's 60th Birthday
Felicitation Fund
Department of Marine Sciences
University of Cochin
Cochin 682 016.

